ASTRONOMICAL TRADITIONS IN PAST CULTURES

Proceedings of the First Annual General Meeting
of the European Society for Astronomy in Culture (SEAC)
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Edited by

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Foreword

In 1993 Bulgaria was the host of two significant conferences on Archaeo- and Ethnoastronomy - the international conference Oxford 4 in Stara Zagora and the Annual European Conference in Smolyan. This fact indicates the great interest and the active work of Bulgarian scientists in that interdisciplinary domain. A few years back, in 1988, the First National Symposium on Archaeo- and Ethnoastronomy was held in Tolbuchin (now Dobritch). It is considered the first of the series of annual meetings in this scientific field in Europe. The Proceedings of the Symposium occupied two volumes of the Bulgarian academic journal *Interdisciplinary Studies*.

The Smolyan Conference was organised by the National Astronomical Observatory Rozhen; the chairman of the Local Committee was Dr. V. Dermendjiev. It was not only a scientific meeting, however. The final session became the First General Meeting of a newly created society, the European Society for Astronomy in Culture (SEAC), which was widely discussed during the previous Annual European Meeting in Strasbourg (November 1992). The General Meeting adopted the Statutes of SEAC and the first Executive Committee was elected (see the documents in the introductory part of this volume). We gratefully acknowledge the role of Prof. C. Jaschek in establishing SEAC and the considerable effort of the first President of SEAC, Dr. C. Ruggles, in completing the SEAC documents and organising this Conference.

This volume contains 20 papers presented at or proposed to the Conference. The first two articles by Dr. Ruggles and by Dr. Murray, are invited lectures that were read in the Smolyan Planetarium. The contributions cover a wide range of subjects - methodology, results of field work, studies of written sources, astronomical interpretation of archaeological finds and ethnological data, and we have tried to arrange them in accordance with their thematic propinquity.

The local organisers are very grateful to all the participants of the Conference for their efficient work. We should note the kind help of our colleagues from the Smolyan Planetarium in organising the public lectures and the Archaeoastronomical photo-exhibition, which was an excellent supplement to the Conference. The Conference itself would not have been possible without the support of First Private Bank and Expressbank. The editors are thankful to the Open Society Foundation, United Bulgarian Bank, Vitosha Insurance Company and Bulgaria Insurance Company for their financial support in publishing this volume.

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D. Kolev

westerly direction; on the contrary, the "preferred direction" as evidenced by stone height gradation - and reinforced by horizon distance data, the presence of prominent hills, and the astronomy - is as often NE as SW. This leads to a fundamental, and as yet unanswered, question: why should a lunar interest be confined to rising phenomena in the north and setting phenomena in the south? Evidence pointing to solar orientations in one direction and lunar in the other would make more obvious sense, forming pairwise symbolic associations such as the setting sun and the simultaneously rising full moon near midwinter. However, the evidence from the four- to six-stone rows quite definitely points to lunar alignments in both directions (Ruggles 1994a: S15-16).

During 1992 and 1993 the survey programme was extended to those three-stone rows where all three stones remain standing. A full report is in preparation, but the preliminary results indicate that a pattern of lunar orientation strongly correlated with alignment upon prominent hills is still evident amongst this second sample of sites, though not as strongly as amongst the longer rows. Of 27 three-stone rows, 11 combine lunar orientation with orientation upon a prominent hill, while 11 more achieve one or the other. Fig. 5 combines the new data on horizon hill summits with those from the longer rows. The pattern of declinations concentrations between +26° and +29° in the north-east and between –30° to –19° in the south-west seem to be strengthened, although more data now fall outside these ranges.

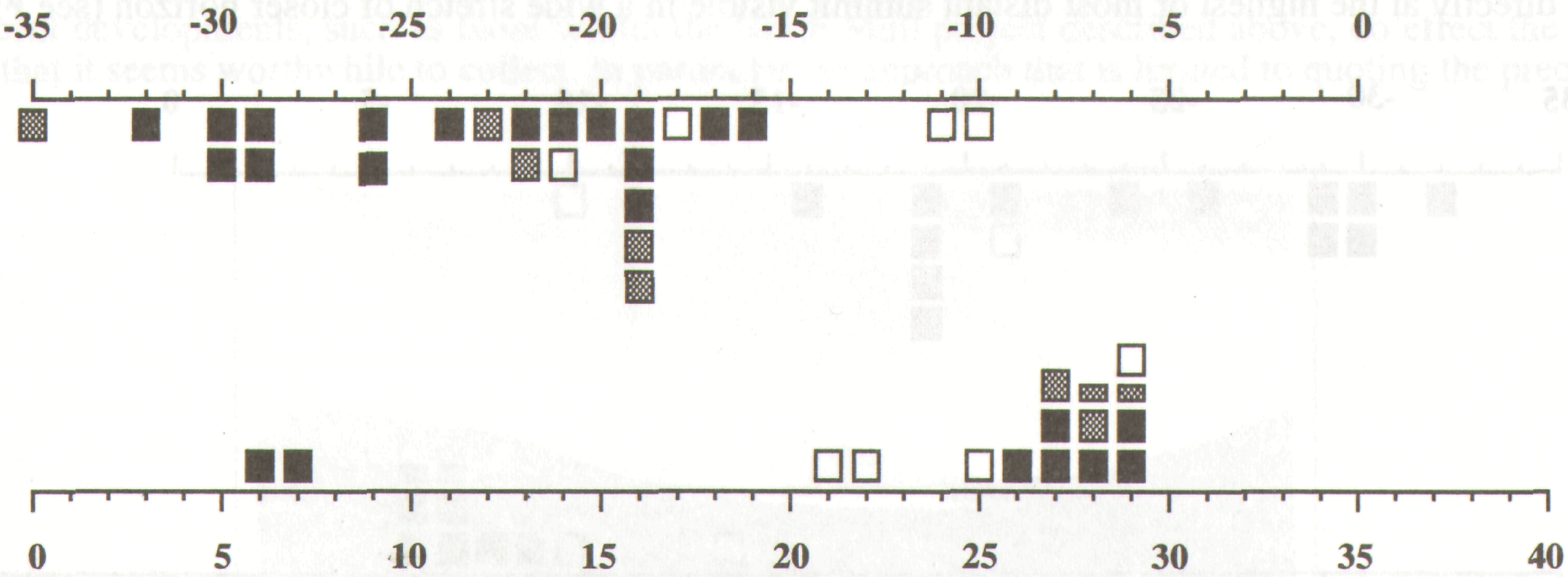

Figure 5. Declinations of prominent hill summits at the three- to six-stone rows of south-western Ireland. For explanation see Fig. 4.

The greatest problem remaining is the fact that the directionality of the sites, as evidenced both from the form of the sites themselves (stone mass and height gradation) and the "indicated" horizons (distribution of horizon distance with azimuth, presence of prominent hills, and astronomy), is as often NE as SW. This is not only different from the properties of similar sites in western Scotland, but raises the awkward question of why lunar indications should be confined to rising phenomena in the north and setting phenomena in the south. It may be that planned fieldwork on the axial-stone circles, which are implicitly unidirectional, may cast some light on this issue.

Discussion

At the second "Oxford" international symposium on archaeoastronomy, at Mérida in 1986, Anthony Aveni asked the question "Whither archaeoastronomy?", raising a number of themes and issues to do with how and why we do archaeoastronomy and what we hope to achieve (Aveni 1989). In the opening address four years later at Oxford 3, I asked not "whither archaeoastronomy" but "whether archaeoastronomy", that is, should archaeoastronomy exist at all as such?

There is no doubt that a considerable amount of high-quality research is now being generated under the twin banners of archaeo- and ethnoastronomy. We have come of age in that we recognise the multi-faceted nature of the evidence and appreciate the need to consider astronomical practice in its full cultural context. We realise that it is meaningless to study astronomy and calendrics in isolation from religion and society. Where astronomical alignments are found amongst monumental architecture, they are likely to be interpreted as symbolic representations of relationships existing within a culture's "world view", not as the elements of

ancient observatories. Valuable as his role was in getting archaeoastronomy on the road, the days of [Alexander Thom's so-called] "megalithic man" are now over.

Nonetheless, archaeoastronomy and ethnoastronomy are still in a state of great flux, striving to find their identity, to define their precise scope and goals, and to establish firm methodological foundations. A key issue, still unresolved, is whether they really merit an independent existence at all: while it is clear that archaeologists, ethnographers and others need to do archaeoastronomical work from time to time, it is less clear - certainly from the outside - that the combination of archaeoastronomy and ethnoastronomy necessarily needs to be recognised as a discipline in its own right. ... If we cannot justify our existence within the wider structure of established academic disciplines, then we must question what we do and why we do it, and question the role and value of our specialist conferences and journals. If, on the other hand, we feel we can justify ourselves, then first and foremost we must go out and do so [by making our work known in the mainstream disciplines]. In addition, we must begin to address some serious questions concerning the academic future of the interdiscipline. Either way, a range of questions needs to be addressed with some urgency if the quality work currently classified under archaeo- and/or ethnoastronomy is to flourish and to achieve the academic recognition it deserves in the 1990s and beyond (Ruggles 1993: 1-2).

[A major problem] is that it is generally unclear precisely what archaeo- and ethnoastronomy encompass and precisely what they are trying to achieve. A widespread perception of the two disciplines amongst their mainstream proponents appears simply to be the collection of data on astronomical practice in different cultural settings. From an anthropological or archaeological point of view the value of merely collecting data, as opposed to trying to derive some meaning from those data, is of very limited interest ... In great many cultural settings astronomical practice is far more likely to be closely related to a shamanic world-view than to be any form of precursor to twentieth-century astronomy in the western world. Thus, the fact that modern astronomers have played a significant part in archaeoastronomical studies has aroused considerable (and often justified) suspicions of ethnocentrism.

... cultural needs and perceptions are all-pervading and social systems are notoriously open-ended; so why should astronomy merit special attention over and above many other factors such as economy, trade, politics, burial practice, diet, and so on? Few would dispute that astronomy should not be studied in isolation from the many other potential influences on a cultural system; the point at issue is whether it deserves to be given special emphasis. If it does, then the reason must be that the study of astronomical observations can perform a special role in the study of cultural systems as a whole (*ibid.*: 3).

At Oxford 3, Nicholas Saunders and I went on to argue that cultural astronomy does indeed have a special role. The key, we suggested, is in viewing the sky as a cultural resource. It is a resource affording many uses to a culture, particularly because it is the only resource within the environment that is not susceptible to physical alteration by human beings. Furthermore, the recurrent phenomena within it are directly accessible to us: they form a part of the environment of another culture that we can accurately reconstruct (within determinable margins of error). Finally, various features within it are common, at various levels, to different cultures. These three properties permit wide-ranging structuralist studies of topics such as the correlation between astronomy and culture, cross-cultural parallels, and the ways in which different cultures interpret and manipulate the same immutable database for different political reasons and ends (Ruggles & Saunders 1993).

However, recognising that cultural astronomy does have a special role within the general study of cultural systems is just the first step. Several further developments are then needed. One of the most important of these is to develop suitable underlying theoretical and methodological principles. If we do not do this, we cannot expect archaeoastronomy to be taken seriously as an academic discipline (Ruggles 1993: 4).

The very quality that gives archaeoastronomy its originality and vitality is also the source of the most fundamental problem in trying to establish these theoretical and methodological principles: the mix of mainstream disciplines that are relevant to, and contribute to, studies in this area. I firmly believe that the root cause of many of the misunderstandings and arguments between archaeologists and astronomers about "megalithic astronomy" in the early days of archaeoastronomy was a conflict of methodological approaches (Ruggles 1988).

Nowadays the problem is much wider, with the involvement of disciplines as diverse as astronomy, history of science, archaeology, anthropology, ethnohistory, ethnography, geography,

Figure 6. The stone row at Ballochroy, Kintyre, Scotland, viewed along the row to the south-west. The three stones represent the remains of a longer alignment of standing stones and cairns.

architecture, art history and the history of religions, each with its own different epistemological perspectives and methodological principles.

In this context, it becomes clear that the "green" versus "brown" methodological divide identified by Aveni [at Oxford 2] is really symptomatic of a more general problem: the lack of a rigorous methodology for *combining* evidence from the main constituent disciplines. For example, it is arguable that Mesoamerican archaeoastronomers have tended to depend too heavily upon ethnohistoric documents as opposed to other forms of evidence. In the absence of any methodological foundations it is impossible to judge (Ruggles 1993: 4-5).

An appropriate methodology for data integration might be founded upon the use of analogical inference in conjunction with a Bayesian statistical methodology (Ruggles and Saunders 1993). This suggestion is currently under investigation (Ruggles 1994b).

It is helpful to illustrate these arguments with a specific example. The stone row at Ballochroy on the west coast of the Scottish mainland in the Kintyre peninsula (Fig. 6), is well known to archaeoastronomers. Archaeologically, it represents the remains of a simple Bronze Age alignment of standing stones and cairns (Burl 1983), a short stone row of which there are two or three hundred examples in western Britain and in Ireland (Burl 1993). How has our general approach as archaeoastronomers changed over the past twenty years and how have our interpretations developed in their turn?

1. In the early days of archaeoastronomy, investigations of this site focused upon the horizon to which the stone alignment points, precise horizon foresights such as notches between mountain slopes, and precise astronomical targets (Thom 1954, 1967: 151-4 & fig. 12.2). Very little thought was given to selection criteria, to the wider archaeological context of the site, or to other sites of similar form in the vicinity, and whether any explanations that seemed to fit this site also seemed to apply to them. Interpretations, implicitly or (as with Thom's so-called "Megalithic Man") explicitly, were related to the aims and goals of the modern astronomers and engineers who investigated it. Ballochroy was interpreted as a high-precision solar observatory.

2. By the time of the first "Oxford" international symposium on archaeoastronomy in 1981, a number of questions were being asked about data selection. Attention was focused upon the number of precise alignments that did *not* have an astronomical interpretation, as well as those that did, of which there were several (MacKie 1974); upon whether similar stone rows nearby incorporated similar precise astronomical alignments, which they didn't (Ruggles 1981b); and upon independent archaeological evidence, and to documentary evidence, all of which showed that the site had been significantly denuded since prehistoric and even historical times, and originally had a rather different form (Burl 1979: 66). In addition, the archaeologists' scepticism towards blatantly ethnocentric interpretations such as prehistoric "observatories" was beginning to be understood and taken on board (Burl 1980; 1981). The reinterpretations that resulted effectively destroyed the idea of Ballochroy as a high-precision astronomical "observatory", replacing it with a perhaps more realistic, but rather vague, notion of Ballochroy as a monument incorporating a low-precision solstitial alignment of symbolic or ritual significance (Burl 1983).

3. During the 1980s, statistical analyses of classes of similar sites proceeded apace (e.g. Ruggles 1984a; Ruggles & Burl 1985). Studies of the western Scottish short-stone rows, considered as a group, showed strong evidence of lunar, rather than solar, significance, but at a low-level of precision (Ruggles 1985). Ballochroy was now seen to be most probably aligned upon the southern moon, at a mid-point in its 19-year cycle that just happens to coincide approximately with the solstitial sun.

   At around this time, a recognition began to develop that attached to statistical precision is a danger. There is a paradox which must be faced. A statistical approach only gives us the power to spot overall trends amongst a large body of data. Human variation, on the other hand, will ensure that any such trends are only of a very general nature. Superficially similar sites may have had complex, differing and changing functions of which astronomy, if it played a part at all, may have entered in various ways, differing from site to site. By sticking to too rigorous a statistical approach we are excluding any possibility of considering this variation and detail (Ruggles 1988). Should we then abandon any attempt to apply a statistical approach to alignment studies? Clearly not: for to do so would be to revert to the practice of simply seeking out and laying great emphasis upon alignments which fit a particular theory and ignoring all others which do not.

4. By the late 1980s it is recognised that, rather than merely paying lip-service to the importance of carrying out alignment studies in their cultural context, we must find satisfactory methods of integrating the cultural evidence into these studies. This relates the "green" v. "brown" archaeoastronomy debate that started at Oxford 2 (Aveni 1989) and continued at Oxford 3 (Ruggles 1993). The brown argument, put extremely crudely and perhaps unfairly, is that very little can usefully be said about alignment studies in the absence of independent cultural evidence. The green counter argument pointed out a tendency amongst American archaeoastronomers to use the presence of the other lines of evidence available to them - ethnohistoric, ethnographic, and written evidence - as an excuse not to consider the fair selection of alignment data or the background archaeological evidence relating to it, but merely to emphasise those alignment data that seem to fit the other evidence (Ruggles 1994b). At Ballochroy we have no independent cultural evidence. Can we then say anything useful about Ballochroy at all?

5. Gradually, a methodology is developing for handling cultural input to alignment studies as a way of solving the statistical paradox. Bayesian statistics is possibly a suitable formalism for incorporating other types of cultural data into the interpretation of new alignment data (Ruggles & Saunders 1993: 20-22; Ruggles 1994b). Where this cultural data demonstrably relates to the people who produced the alignment evidence, this is relatively simple. But what if this is not the case? Here we must effectively use a "highest likelihood" approach to the cultural input. Where there are arguable relationships with other people about whom we do have such evidence, we can proceed by analogy (Ruggles & Saunders 1993: 18-19). Where there are not, as at Ballochroy, we must strive for them: for example the work of Frank and others in the Basque country (e.g. Frank & Patrick 1993) points the way to certain cultural and linguistic continuities that might run right link down to the present day. But we must face the fact that we may never have any close cultural analogy and find a way to proceed in its absence. In this case, we can still try to identify selection criteria and be objective. In doing so we are of course instilling our own cultural input: objectivity is itself a cultural relative (Ruggles & Saunders 1993: 17-18). However, since our interpretation must be formulated within the conceptual framework of twentieth century Western science (Midgely 1992), this is still both appropriate and valuable, provided that we recognise its limitations.

6. The current work described in this paper is attempting to understand monuments such as Ballochroy in terms of their place in the prehistoric landscape - both the physical landscape and the ideological (ritual and ceremonial) landscape. We are using Geographical Information Systems in an attempt to visualise the prehistoric landscape and try to define the role of the stone rows within it. This enables us to relate ideological symbolism relating to astronomical bodies to a wider symbolism - upon prominent mountains and other significant features in the natural landscape - that might have influenced the placement, design and orientation of ceremonial monuments. At the methodological level, we are merely undertaking exploratory data analysis: but the explorations are documented, all the available data can be visualised (not only those that fit a particular set of ideas and models), and statistical investigations can be couched in Bayesian terms.

While "alignment studies" - studies of the possible alignment of architectural structures upon horizon astronomical events - have moved out of fashion (e.g. Hicks 1993), there is a still a central place for them within archaeoastronomy. Orientation is an important aspect of site design and orientation trends and patterns are evident in many groups of sites; and there is plenty of evidence that astronomical considerations have influenced the orientation of prehistoric ritual and ceremonial architecture in the prehistoric British Isles.

More generally, it is clear that we as archaeoastronomers need to formulate acceptable general methodologies for the selection of data and the integration of diverse data. In fact, this need gives cultural astronomy itself a further *raison d'être* and potential strength. This is because the interdiscipline may now be able to lead the way to new cross-disciplinary approaches within their parent disciplines. We are forced to face issues which established, compartmentalised disciplines such as anthropology, archaeology and ethnohistory are able (and even keen) to avoid, despite recognising the problem. By seriously tackling such issues we can turn necessity into a virtue (Ruggles 1993: 5). We may actually (in one small way) start leading critical methodology in cultural studies as a whole.

The days of archaeoastronomy as pure description are gone: archaeoastronomy must yield explanation, and hence its methodology must develop in relation to developments within the parent disciplines of archaeology and anthropology.

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The limits of cognition in the archaeoastronomical interpretations

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Abstract. The object of archaeoastronomical cognition is the aim of archaeoastronomical interpretation. However the lack of literacy in ancient societies deprives archaeoastronomical science of direct evidence. Very often alternative hypotheses are equivalent. That is why a specific logical-methodological approach to both study of ancient astronomical culture and the choice of principles of verisimilitude of archaeoastronomical hypothesis is necessary.

The term "archaeoastronomical hypothesis" is determined in this paper. Procedures realizing the connection between facts traditional for archaeoastronomy and archaeological finds are determined.

The purpose of this work is to ascertain how far the limits of cognition reach in the investigation of structure and functioning of a given archaeoastronomical object, having in mind the whole cultural-technological state of the ancient society.

Examples of archaeoastronomical interpretations of archaeological objects on Bulgarian land are given.

Резюме. Предметът на археоастрономическото познание е цел на археоастрономическата интерпретация. Отсъствието на писменост у древните общества, обаче, лишава археоастрономическата наука от явни доказателства. Много често алтернативните хипотези са еквивалентни. Ето защо е необходим специфичен логико-методологичен подход към изучаването на древната астрономическа култура и избор на принципи за правдоподобност на археоастрономическата хипотеза.

Дефиниран е терминът "археоастрономическа хипотеза". Определени са процедурите, реализиращи връзката между фактите, характерни за археоастрономията и археологическите находки.

Целта на тази работа е да установи, докъде се простират границите на познанието при изследване на структурата и функционирането на даден археоастрономически обект, като се има предвид цялото културно-технологично състояние на древното общество.

Дадени са примери за археоастрономическа интерпретация на археологически обекти по българските земи.

In the last few years the philosophical literature dedicated to the methods of scientific knowledge allocates a considerable role to the analysis of the origin and development of natural scientific knowledge; and in particular - to the origin and development of astronomy! Some works of contemporary epistemology directly concern the problems of the origin and evolution of scientific knowledge.

What does interpretation in archaeoastronomy mean? "Interpretation" is a semantic notion with a significant role in science. Interpretation in archaeoastronomy attaches values to the initial data (contained in the archaeological objects and finds) as a result of which all correct notions acquire meaning in the process of logical consideration. After that, a separate and deliberately built model is obtained. The logical and factual truth, as well as the analytical and synthetical considerations in archaeoastronomy, are determined by the notion of interpretation (Frolova, ed., 1986).

It seems that archaeoastronomy touches the problem of the plausibility of its interpretation earlier than the other interdisciplinary sciences of that type. The reason for this is the specificity of its object of knowledge. Thereby it was explained that the notions "interpretation" and "archaeoastronomical interpretation" in archaeoastronomy are often synonyms.

The attempts to explain some archaeological monuments as astronomical instruments used by ancient people are dated back to the middle of the eighteenth century (Radoslavova 1988). These attempts are purely amateur, and do not apply scientific methods in searching for and finding scientific facts. At the same time, it is characteristic of these interpretations that they have been aimed at explaining something perceived by the senses and the sub-conscience. This situation has been considerably changed by the application of mathematical - geodetic approaches for the investigation of these objects, applied for the first time by A. Thom and J. Howkins (Cooke et al. 1977). In this period the research was focused, not on the reasons for the creation of these astronomical "instruments", but on the documenting of their remains and the objects which they had been "aimed at". These objects, as a rule, admitted a strict study of their peculiarities and the regularities in their orientations. Initially, the mathematical - geodetic investigations didn't invoke a particular necessity for interpretation as a procedure of knowledge. It was necessary to acquire the "external appearance" of the objects in order to select their most significant parameters (which could be directly measured and fixed) and the existing relations between them.

Examining the architecture and orientation of the ancient monuments and cult buildings, archaeoastronomers have noticed that two kinds of facts should be distinguished - accessible and inaccessible for direct observations. Since the objects of the first and the second kind are closely connected, their development presupposes the considering of these relations. As a consequence of this, the term "interpretation" is traditionally connected with the procedure of establishing the connection between archaeological monuments and celestial phenomena and objects as well as with the world of human necessities and social traditions.

The problem in interpretation became particularly apparent in archaeoastronomy in the last few years. At the same time it is evident that functional dependences found in the process of cognition, which connect the instrumentally measured archaeological objects, acquire indisputable qualities of truth and become obvious to everybody. As for the interpretations on the basis of lost data (relief, architectural elements, etc.), they have always been the subject of strong arguments and cannot be confirmed directly and uniformly.

The level of reliability of the archaeoastronomical hypothesis and interpretation can be estimated by the application of statistical methods. Most often our purpose is to estimate whether the determined orientations coincide with a real astronomically significant direction.

To make a statistical analysis of the data from different investigations is not so difficult, but to draw a final conclusion that the given archaeological object has also been used for astronomical observations is not so easy. We must have in mind other considerations. For example we must study well the historical conditions, the epoch in which the equipment was used, and the people who visited it. We shouldn't use one and the same approach for objects with very different geographical locations, but we should keep in mind that comparative analysis is useful and that the ancient people didn't always need precise observations. Hence, the approach to every examined archaeological object must be individual and the data must be objectively selected (Hawkins 1964).

Arbitrary astronomical data based on the position of the Sun, the Moon and the planets turn out to be less precise, having in mind the slow change of the terrestrial axis slope or the orbits of the celestial bodies mentioned. Besides, for lack of written sources, it is impossible to ascertain whether ancient astronomers have recorded the first shine of the Sun, the moment in which the solar disk is divided in half by the horizon line, or the last phase, when it still touches the horizon. The indefiniteness is increased by the impossibility of establishing whether the horizon had the same lay and vegetation. All these ambiguities lead to the fact that the error in defining the epoch of these astronomical instruments' influences by astronomical methods reaches several millennia (Hawkins in collaboration with White 1970).

Orientation by the stars can serve as a basis to define more precisely the time but the uncertainty about just which star the equipment was pointed at, combined with the inevitable errors in constructing, depreciates completely the astronomical method for ascertaining the real epoch of creation and use. For each arbitrary period (1000 or more years) many stars will have one and the same declination in different time.

What does "archaeoastronomical hypothesis" mean? By definition, the hypothesis is a system of conclusions by which, on the basis of a number of factors, conclusions are drawn for the existence of an object, relations or reasons for phenomena.

These conclusions should not be regarded as absolutely reliable. The necessity of a hypothesis in archaeoastronomy emerges when the relations between the archaeological objects and the reasons for their construction are not clear.[1] After such a verification the hypothesis either becomes a scientific theory or it changes; or it is rejected if the verification has a negative result. The testing of an archaeoastronomical hypothesis should correspond to all rules of scientific research and scientific verification in its philosophical meaning (Frolova, ed., 1986).

A universal and, if possible, interpretation principle is sought for the big entities of concrete events and mathematical - geodetic data. The purpose is to make a transition from the reconstruction of the former events to obtaining facts and knowledge for the origin of scientific and practical astronomical knowledge (Gardin 1979).

Two approaches are possible in the construction of the theoretical models. The main characteristic of the first one is the creating of theoretical models providing a whole global depiction of these societies' knowledge and skills in the field of theoretical astronomy (mythological cosmogony and cosmology) and practical astronomy (observations and calendar). In the second approach we are not interested in the global meaning of the astronomical knowledge about the society. For this reason the archaeoastronomers treat separate facts and pieces of information, they interpret them for the sake of themselves, taking theoretical constructions by separate private fields of science:

What is the cultural technological state of the society and its reflection on the archaeoastronomical interpretation? [2] Thus, it is difficult to accept and interpret this conclusion. The basic reason for this hypothesis is that when human established as social beings, evolution became practically interrupted and the only way for adaptation became the changing of the behaviour, controlled by the culture.

Prognostication methods must necessarily exist in the cultural system as an instrument of adaptation to the environment. The changes of weather and climate, harvest, demographic situation of the tribe placed in very severe conditions, were the unique factors for survival. The main supposition is that at a very early stage of the cultural evolution, a correlation between variations of the local climate factors and biological phenomena had been discovered on the one side, and shifting of the planets on the other. This correlation is connected with the influence of solar activity on the Earth atmosphere and biosphere and with the statistical relationship between the solar activity level and the planet configurations. The discovery of such a prognostic algorithm was significantly easier because the influence of solar activity on terrestrial phenomena during the examined epoch was deeper and more significant than the present one, due to the relatively low Earth magnetic moment in ancient times. The explanation of this strong interest of palaeolithic man in practical astronomy poses many questions. It is accepted in general that the thinking of the primitive men was of the same type as ours, but this is quite a debatable question.

It is evident that we know little about the rituals, psychotechnic methods and imprinting probably used by our distant ancestors. The signs of information fixing are many and are geographically widespread. Further, this information was kept in calendrical systems in the form of pictograms and special structures in the most ancient ornaments. It became necessary to build up a specific social organization to store and recreate extensive, complex knowledge and information. That was how the priests' cast appeared. Initially they dealt with the social and economical problems of the community, set measures for stability, and took care for sanitation and health. To fulfil these functions effectively it was very important to have high authority for which series of measures were set. One of the brightest examples of the priests' omnipotence was the special spectacular showing that even the sky obeyed. They were able to order the Moon or the Sun to fade away after continuous ritual procedures and a preliminary secretly calculated day. Thus, the ability to predict the Sun and Moon eclipses met social needs. It is very probable that astronomy (including the building of observatories) was completely of the priests' competence (Eliade 1987).

A great amount of knowledge had been stored during the period of the priests' domination. They were an element of an entire ideological system of the first contemplation of the world elaborated in all details. Astronomical knowledge in that system apparently played an important role. We shouldn't doubt that the empirical information for the movement of the celestial bodies and their synchronous changes in nature during that ancient time was part of a special conception then called astrology. All empirical knowledge was closely integrated with social and cultural phenomena - magic guessing and signs, which were very important in the culture of the ancient people. Palaeolithic astronomy, which rose in connection with the

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1 The hypothesis itself needs to be verified because of its probability character.

2 Archaeoastronomical investigation results have shifted the beginning of the systematic astronomical observations back to about 20 millennia BC.

necessity for co-ordinating the social and economical rhythm of the primitive community with natural biospheric cycles, was the most significant part of the ancient cultural prognostic equipment which allowed them to predict the beginning of events which were unfavourable for the society.

The appearance of an eclipse would require its including in the deeply mythologized agricultural activity and its connection with a suitable ritual or sacrifice. It could lead to the use of the observations of the Moon phase for drawing images with a different calendar consequence. Different types of signs were definitely used for different purposes in the whole agricultural and ceremonial cycle and were not recalculated from one to another. It was not necessary to have any equipment to create such a regional calendar, showing the moonrises and moonsets. It was enough to register them and just to mark the new Moon. Their period is not longer than 3 - 4 days which requires very careful following of the last hours of the second quarter and the first hours of the first quarter of the Moon. So the effect of calendar marking could be seen in their prognostic indication of the stored images containing periods of time symbolically and ceremonially confirmed for ancient social and agricultural practice. The analyses of the prognostic actions probably realized by means of "reading" the Moon images has shown that different consequences and combinations of the Moon phases were practically used in an algorithm existing in those ancient times for the "reading" (understanding).

Undoubtedly, in the chronological limits of the moon sanctuary existence as in Bailovo, the moon was accepted as a divinity. It could not be excluded for the moon phase images on the rock to have been just a simple reflection of the cult towards the Moon and its different faces (Stoev and Muglova 1992).

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Astronomical Traditions in Past Cultures
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National Astronomical Observatory Rozhen, 1996
V. Koleva and D. Kolev, eds.

Methodological considerations concerning the archaeoastronomical research of Sarmizegetusa - Regia, Romania. First part

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Abstract. The absence of convincing results of archaeoastronomical research on the Dacian civilization (I cent. BC - I cent. AD), requires the proposal of a new research methodology, presented in this paper, based on the methods and instruments of the astronomy from this epoch.*

Резюме. Отсъствието на убедителни резултати от археоастрономическо проучване на цивилизацията на даките (I в. пр.н.е. - I в. н.е.) изисква нов изследователски подход. В доклада се предлага методология, базираща се на астрономическите методи и инструменти от тази епоха.

Introduction

The ancient capital of the Dacians, Sarmizegetusa - Regia, lies in the Orastie Mountains, Romania. In the sacred precinct, in the vicinity of the fortress walls, 11 round and rectangular sanctuaries were discovered. They were built at different times, during the reign of Burebista (82 - 44 BC) - the limestone construction, and at the beginning of the second century AD, in the years of Decebal's reign (87 - 106 AD) - the andesite constructions.

Among these buildings erected on the X-th and XI-th terraces we come across the Great Limestone Sanctuary (with 4 rows of 15 plinths), the Small Limestone Sanctuary (with 3 rows of 6 plinths), the Great Round Sanctuary, with a diameter of almost 30 m, the Small Round Sanctuary - with a diameter of almost 13 m, two other rectangular andesite sanctuaries, the Great Rectangular Andesite Sanctuary (with 6 rows of 10 elements each) built on top of an older limestone sanctuary and last but not least, the altar known as "The Andesite Sun".

Archaeological discoveries have proved that these sanctuaries are not a singular case in the cultic and spiritual life of the Dacians. Sanctuaries are also present at Costesti, Racos, Brad, Barbosi - Galati, Pecica, Fetele - Albe, Bitca Doamnei, Dolinean (Republic Moldova), but of smaller size of course, and lacking the stateliness of those at Sarmizegetusa - Regia (Daicoviciu 1972; Glodariu et al. 1988).

About the spirituality of this people, except some accounts of the ancient writers (Herodot, Strabon, Porphirios, Iordanes), concerning some remarkable knowledge in astronomy and in medicine, we lack much data nowadays. The research of archaeoastronomy presented here, tries to complete the knowledge that we have about the Dacians.

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* In 1982 the accurate number of pillars from the Great Round Sanctuary's configuration Sarmizegetusa - Regia was discovered. This fact demonstrated that all calendars attributed to the Dacians, which were based on the pillars' number known before 1982, therefore an inaccurate number, were wrong. Therefore, the methodology to search for calendars through the counting of pillars was also wrong. The consequence was that historians and archaeologists lost their trust in the methods of exact sciences applied in their domains.

This paper is dedicated in the first place to historians and archaeologists in the attempt to regain their trust in mathematics and astronomy's methods. The author expresses his regrets that sometimes the strictness of the account was put in front of the desire of being understood as best as possible by reader less conversant with approached domains.

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Mathematical-astronomical study of Thracian cult constructions (tombs)

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Abstract. The paper comprises: Introduction; Technical means - architectural and geodesic documentation; Astronomical-geodesic measurements and observations; Statistical processing of the data; Historical and mathematical studies; Historical and astronomical studies; The Thracian sacred foot (TSF); Definition of the nature of the sepulchral constructions as a special type of cult monuments; Conclusions; Notes and references. Three tables and 23 figures illustrate the text.

Резюме. Докладът съдържа: въведение; технически средства - архитектурна и геодезична документация; астрономически и геодезични измервания и наблюдения; статистическа обработка на данните; исторически и математически изследвания; исторически и астрономически изследвания; Тракийската свещена стъпка; дефиниране на същността на погребалните конструкции като особен тип култови паметници; заключение; бележки и библиография. Три таблици и 23 фигури илюстрират текста.

Introduction

The author's interest in the problems which emerge with the discovery and investigation of cult sites in the lands of the Thracians dates back to 1982, when Bulgarian archaeology enriched its assets with two new monuments of extremely high academic value: the tomb dated to the Hellenistic period from the village of Sveshtary near Isperih in Northeastern Bulgaria,[1] and a tomb from the Roman period discovered near the village of Babovo, Rousse district.[2] The author participated in the work of research teams with the task of organizing the precise graphic documentation of these monuments.

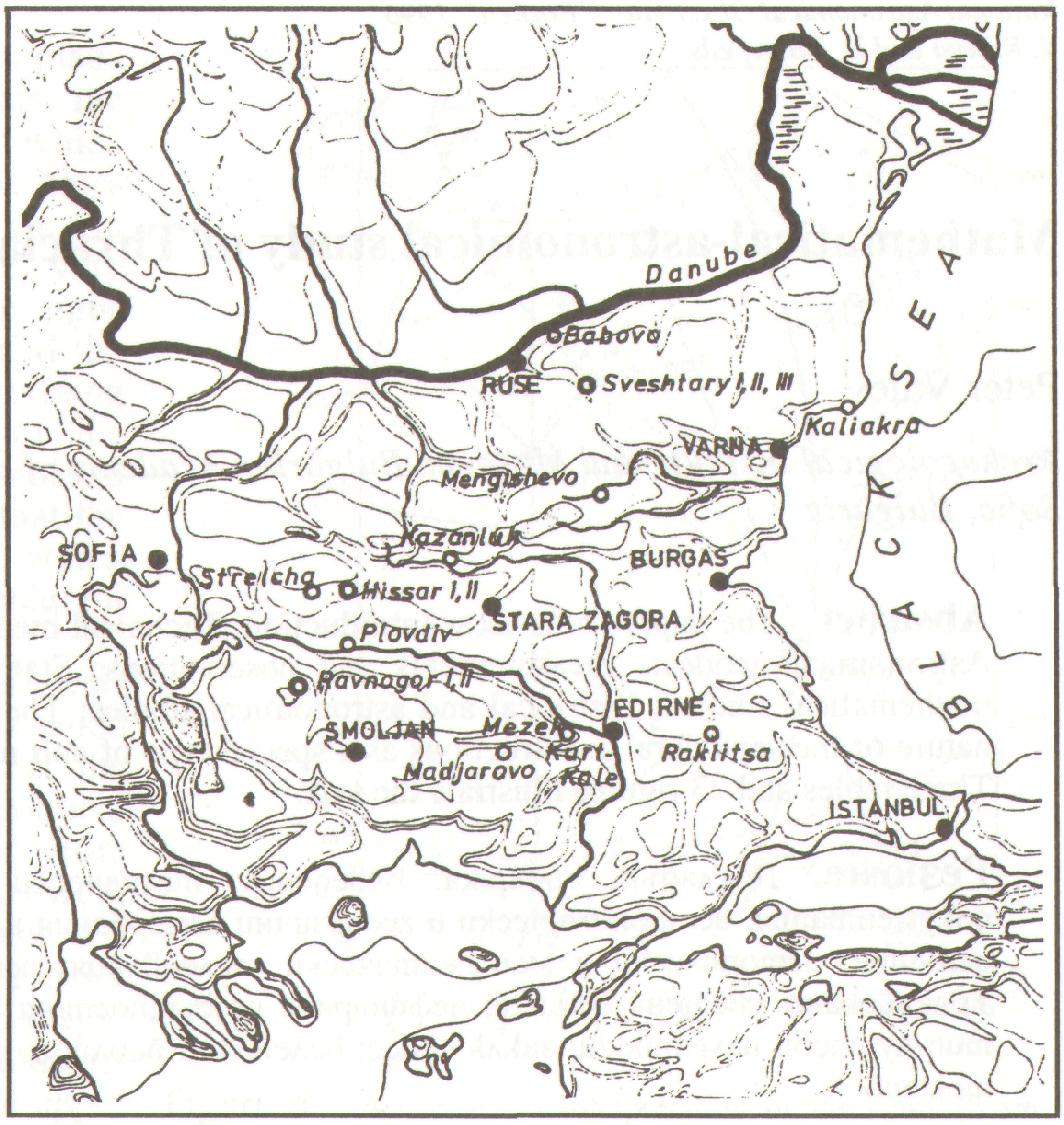
The metric data of these two sites and their orientation proved to be very intriguing. The size of the chambers and of some architectural details in the Sveshtary tomb made it possible to establish remarkable mathematical dependences and to derive a linear module, perceived by the author as a Thracian foot, which subsequently proved to have been used in almost all Thracian tombs built over a relatively long period of time: from the 5th century BC to the 4th century AD.[3] The dimensions of the tomb near Babovo held another surprise. Their ratios led to astronomical constants which are characteristic of the visible movement of the Sun and are valid only of the geographic latitude of that archaeological site and of the time when the monument was built.

This suggested that it might be a good idea to check - after precise documenting of many sepulchral constructions - whether the ancient builders indeed applied knowledge in mathematics and astronomy while designing these tombs. Secondly, whether this knowledge reflected the level of ancient science, and finally whether they were a component of the ancient ideology. A positive answer to all these three questions would have added considerably to existing knowledge on the Thracian cult of the dead, of the Sun and of the Earth. This would have facilitated the deriving of a more accurate definition of the nature of the sepulchral constructions as a special type of cult monuments. The positive answer also made it necessary to find out to the maximum possible extent the relation between Thracian cult construction and the construction of similar monuments throughout the rest of the ancient world.

The problems which would undoubtedly have occurred would have been solved through purely technical means: by elaborating the architectural and geodesic documentation of the well preserved Thracian tombs in the territory of present-day Bulgaria, using astronomical and geodesic measurements and observations, statistical processing of the data, followed by historical-mathematical and historical-astronomical investigations.

However, other problems were also anticipated: historical and archaeological problems related to the dating of the monuments investigated, philosophical, religious, etc., which were surmounted with the help of specialized literature, through consultations with other archaeologists, art historians and philosophers.

From the brief description of the task facing the author, it can be seen that it should have been developed in the form of a monograph, because each new step needs serious argumentation. This is why it was necessary to cover at least two-thirds of the known Thracian tombs in the present study. The outer dimensions of the constructions were very important for the study,[4] hence the need of drilling. The lack of sufficient finances prevented the author from implementing the task as initially planned. By opting to present it in the form of a study, the author is clearly aware that a number of important points need more detailed and comprehensive proof.



The investigated 17 Thracian tombs are marked at the map of a part of Balkan Peninsula

I. Technical means

A. Architectural and geodesic documentation

Since we have already accepted the term "architectural-geodesic plan" to be used for the graphic documentation of immobile archaeological monuments for which large scales have been used (1:100, 1:50, 1:25 or 1:10),[5] we would like to explain that this term is also valid in the cases when the documentation is intended for archaeoastronomical studies, but with the following qualitative improvements:

- the deformations of the constructions are noted by coordinating the basic points in the external and internal contour; the polar method of registration is applied for the purpose, then the polar coordinates are transformed into rectangular ones;[6]

- the linear measurements are performed repeatedly (at least three times) using a steel tape-measure and with precision of ± 1 mm when the architectural details are above 1 m, and with precision of ± 0.1 mm when their length is below 1 m;[7]

- the data are presented in tabular form (Table 1);

- the graphic images are correlated with the mean results of the statistical processing of linear measurements (Fig. 1);

- the facade plans and the cross-sections of the constructions require special attention.

B. Astronomical-geodesic measurements and observations

1. Since most of the sepulchral constructions are symmetrical to the line passed through the middle of the entrances of the chambers having a chain-like orientation, this line is perceived as an axis, then it is taken out and through observations of either the Sun or the Polaris, its astronomical azimuth is determined, or the deviation from the closest main astronomical (cardinal) direction.[8]

Table 1. The ancient tomb near the village of Babovo - actual and theoretical dimensions. Example with the elements of the first antechamber

Elements	Dimensions according to D. Ivanov (m)	Dimensions according to P. Valev							
		Actual				Theoretical			
		Number of measure-ments	Max. deviation from mean values (mm)	Mean values			Deviation		
				in meters	in feet	In feet	in feet	in mm	in %
1. Thickness of the facade wall	0.60	4	± 9	0.597	2.23	2.69	- 0.46	-123	- 17.1
2. Length	2.96	3	- 4	2.967	11.09	10.73	+ 0.36	+ 96	+ 3.4
3. Total length (without the posterior wall)	3.56	2	±12	3.564	13.32	13.42	- 0.10	- 27	- 0.7
4. Thickness of the posterior (southwestern) wall	-	-	-	0.585	2.19	1.98	+ 0.21	+ 56	+10.6
5. Width of the facade wall	-	2	± 3	3.242	12.12	12.10	+ 0.02	+ 5	+ 0.2
6. Width of the main entrance	1.50	3	±15	1.505	5.62	-	-	-	-
7. Average width	1.92	-	-	1.926	7.20	7.18	+ 0.02	+ 5	+ 0.3
8. Width of the entrance	-	3	± 7	1.887	7.05	7.05	± 0.00	± 0	± 0.0
9. Width before the dromos	-	3	+13	1.964	7.34	7.31	+ 0.03	+ 8	+ 0.4
10. Length of the lateral walls (total construction length)	-	1	± 0	4.140	15.47	15.40	+ 0.07	+ 19	+ 0.5
11. Thickness of the lateral walls	-	-	-	0.669*	2.50	2.52	- 0.02	- 5	- 0.8
12. Height from the floor to the apex of the vault	-	-	-	-	-	11.50?	-	-	-
13. Height from the floor to the ridge of the vault	-	-	-	-	-	14.00?	-	-	-
14. Difference in the levels between the threshold and the brick floor	1.08	-	-	-	4.04?	4.00?	+ 0.04	+ 11	+ 1.0
15. Height from the floor to the step of the vault	2.96	-	-	-	11.06?	11.00?	+ 0.06	+ 16	+ 0.5
16. Height from the floor to the apex of the vault	-	-	-	-	-	14.50?	-	-	-
17. Height from the floor to the ridge of the roof	4.80	-	-	-	17.94?	18.00?	- 0.06	- 16	- 0.3

* *Indirectly obtained dimensions*

2. In order to verify the hypothesis that the axis of a certain construction points to the place in the horizon in which the Sun, the Moon or some bright star rises or sets, it is necessary to have data about the visible horizon. If it is, e.g., the line of the sea surface, it is necessary to measure the depression of the horizon,[9] whereas if the ridge of a mountain or some other obstacle is perceived as the visible horizon (Fig. 2), it is necessary to measure and draw a panoramic image of the line of the visible horizon, or at least to identify its angular elevation at its point of intersection with the vertical plane passing through the axis of the construction.[10]

C. Statistical processing of the data

1. At this stage of the study, we have chosen to use relatively elementary statistical methods. In the tables containing linear data on each archaeological site (Table 1), it has been our aim to make at least three measurements and to prevent an influence on the maximum deviations from the mean values as a result of gross errors in the course of the linear measurements.[11]

2. Since there are still very few sepulchral constructions with azimuths determined through astronomical observations, some statistical characteristics are to be determined in the future. Bearing in mind the results of similar measurements,[12] it may be assumed that the measuring of the azimuths of the tombs using a compass would not be advisable for the purposes of the archaeoastronomical analysis.

3. The evaluation of the precision of the Thracian foot derived by us is also a matter of a future special study.

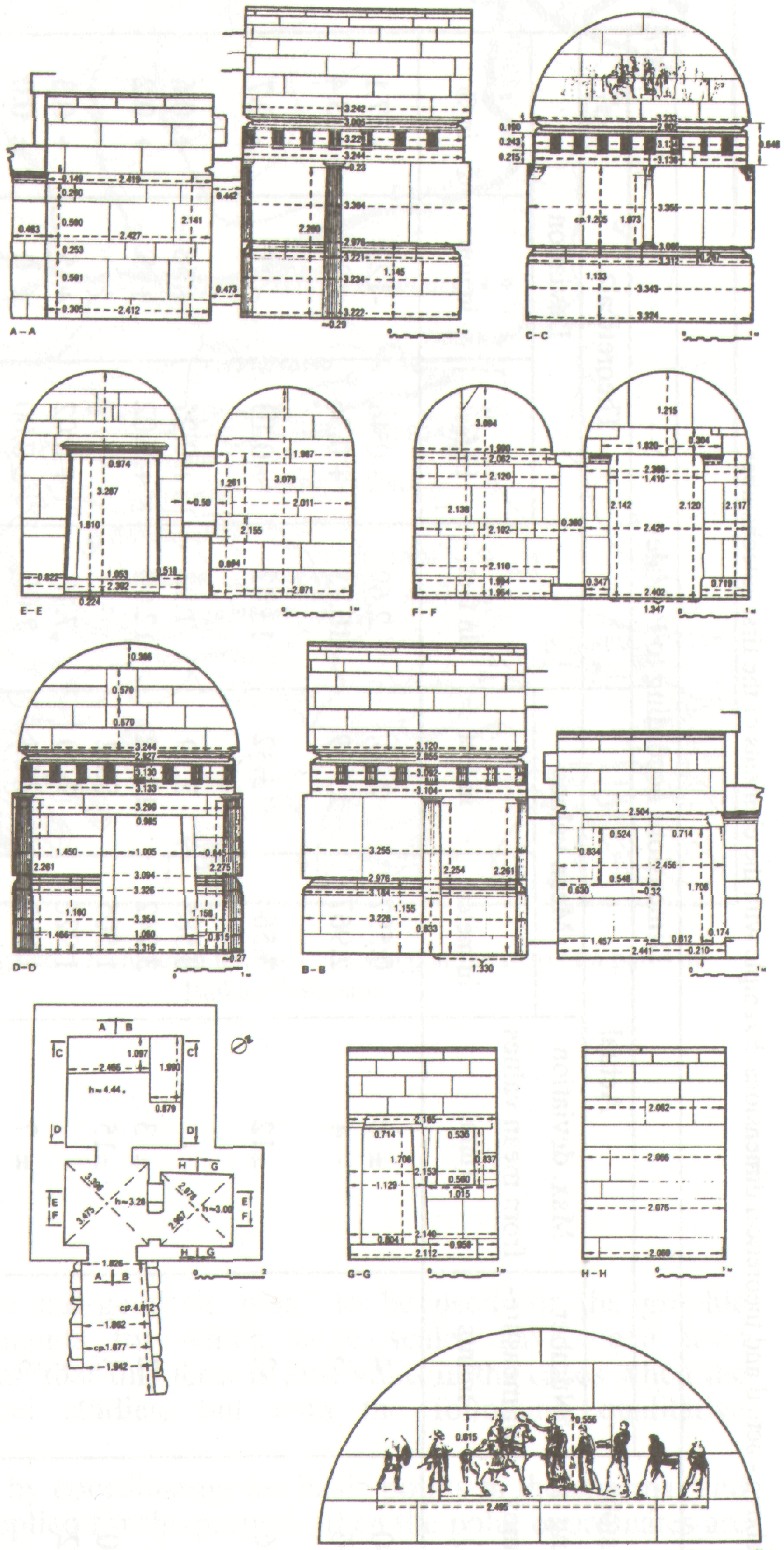


Figure 1. Thracian tomb near the village of Sveshtary (Sveshtary II). Graphic presentation of the facade plan (example).

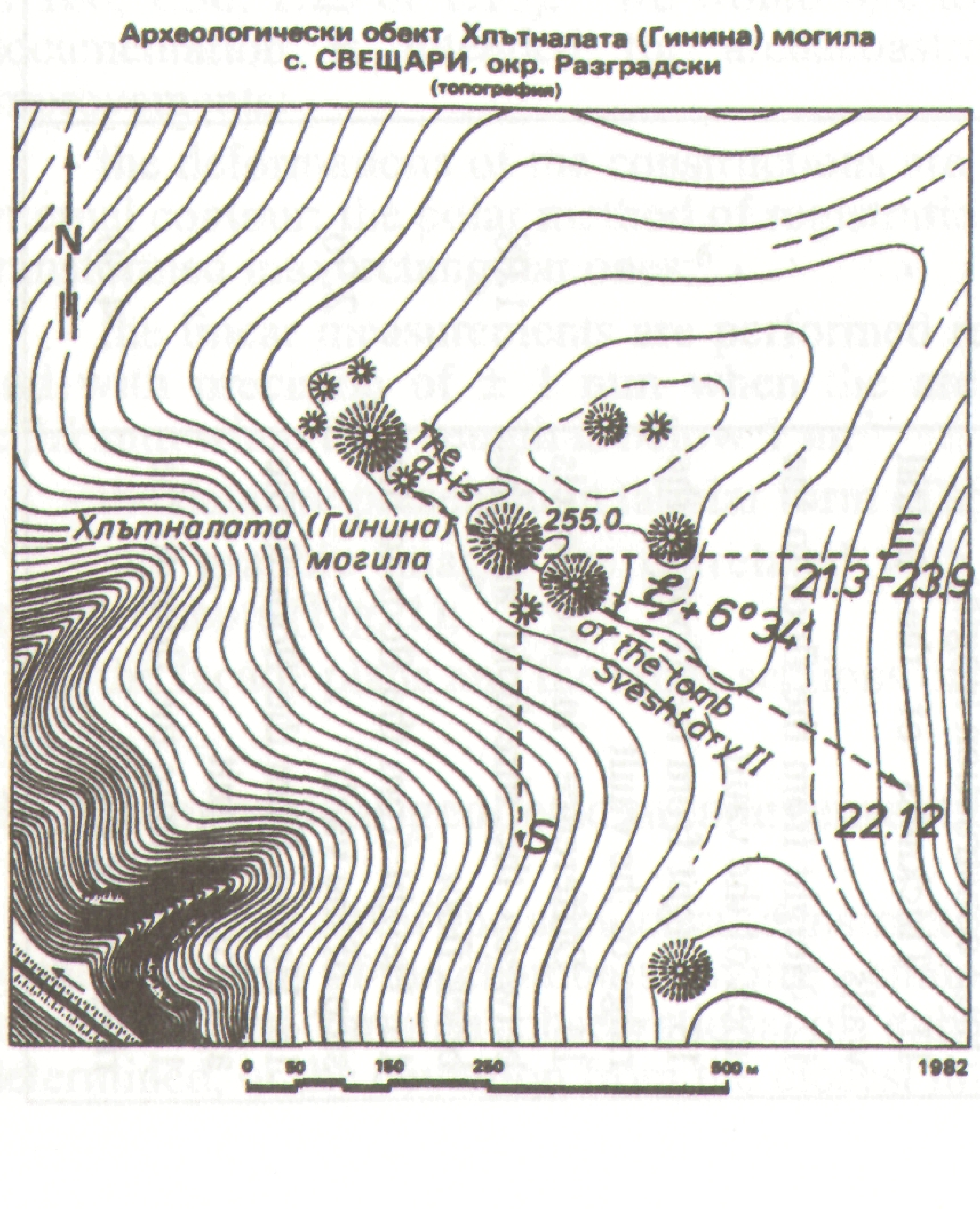


Figure 2. Thracian tomb near Sveshtary. Plan of its localization with respect to another tumulus.

II. Historical and mathematical studies[13]

1. The main geometrical figures registered in the 17 tombs studied are: isosceles triangle, parallelogram, rhombus, rectangle, square, trapezoid (sometimes rectangular) and circle.

The cross-sections through the so-called "false vaults" of some tombs are isosceles triangles (Mezek). A system of parallelograms and rhombi is found in the roof structures of antechambers (Kurt-Kale and Strelcha) and burial chambers (Plovdiv). The *dromos* of all tombs, as well as some antechambers and burial chambers (Plovdiv, Hissar I and II, Mengishevo, etc.), have a rectangular plan. Only the burial chamber of the tomb near Madjarovo and the antechamber of the Sveshtary tomb (Sveshtary II) are square. The first antechamber of the tomb near Babovo is trapezoid in shape in its horizontal plan. Most of the entrances to the sepulchral constructions studied are trapezoid in shape. The entrances to the burial chamber and the lateral chamber of the Sveshtary tomb are shaped like a rectangular trapezoid. The circle is the privileged shape reserved for burial chambers (Raklitsa, Mezek, Kurt-Kale, Ravnogor I and II, Strelcha and Kazanluk).

2. While the geometric figures listed above are visually present in the planning of the tombs, different Pythagorean triangles (3:4:5, 5:12:13, 8:15:17, 20:21:29) play an auxiliary role, being used for plotting right angles. In addition to the Pythagorean triangles, squares, circles, and a system of squares and circles inscribed into one another have also taken part in the designing process.

a) Among the several listed rectangular triangles, which a sum of the squares of the catheti equals the square of the hypotenuse, only the triangle having a 3:4:5 ratio of its sides had a sacral importance and it is known as the sacred Egyptian triangle (SET).[14] It was most widely used in the design and construction of pyramids and temples even at the time of Pharaoh Snofru (Fig. 3a), the founder of the powerful 4th dynasty in Egypt. Chephren was the first to use SET as a meridian triangle in a pyramid (Fig. 3b). We have found that SET was used for the designing of the following Thracian tombs: Ravnogor I and II, Plovdiv, Hissar I, Mengishevo, Sveshtary I and II, and Babovo.

b) In our opinion, the claim that SET is at the basis of cult construction during all ages has been substantiated not only with the opinion of other researchers.[15] Our own evidence is directly related to cult construction in Egypt and Thrace, but it would not be possible to report it here extensively, because this would go beyond the scope of the shortened version accepted for this study.

If SET had undergone a transformation from an auxiliary means for plotting right angles into a sacral object, a similar situation is the symbolic (indirect) presence of the square and circle in a considerable number of the sepulchral constructions studied: Madjarovo, Raklitsa, Sveshtary I and III, and Babovo, not as the shape of one chamber or another, but as a reminiscence of the ancient problem of finding the surface of the circle. The mathematical problem of finding a circle and a square having the same surface was transferred to cult construction as well. Perhaps this is a peculiar attempt to express an identical attitude to the Sun and to the Earth with their symbols: the circle and the square accordingly, i.e. their equal importance to human life (and reincarnations). In practice, this meant that one element of a certain sepulchral construction, perceived as the side of a square, could be used to calculate other elements of the construction, e.g. the radius, diameter and circumference of a circle having the same surface as the square. Sveshtary I (Fig. 4) is the most typical example, because there the dimensions of the burial chamber are determined by means of SET and the mathematical problem of finding the surface of the circle.

c) The Thracian tomb near Kazanluk is a typical example of the design of a sepulchral construction using a system of circles and squares inscribed in one another (Fig. 5).

3. We have already expressed the assumption that in studying SET, the ancient mathematicians probably simultaneously came across the three most popular mathematical constants:

$M_{\varphi} \approx 0.618$ (the major key of the golden proportion),

$\sqrt{2}$ (the ratio between the diagonal and the side of the square) and

$\sqrt{10} \approx \pi$ (the ratio between the circumference of the circle and its diameter (Fig. 6).[16]

a) Ever since the formation of the ancient Egyptian canon in architecture, painting and sculpture, designated by some authors with the following sequence of letters: RIEN•SGA (Fig. 7), people came to the idea about a series of numbers, later rediscovered by the mediaeval mathematician Leonardo Pisano (Fibonacci) and named after him, in which the ratio between any two successive elements in the series gives the approximate value of M_{φ}.[17] With the increase in their serial number, the ratio between them tends more and more accurately towards M_{φ}.

In the course of the investigation of the 17 tombs built during the Hellenistic and Roman periods in Thrace and Moesia Inferior, we found that the use of the golden proportion was most frequently applied with the help of numbers from the Fibonacci series, more often expressing surfaces and not perimeters or

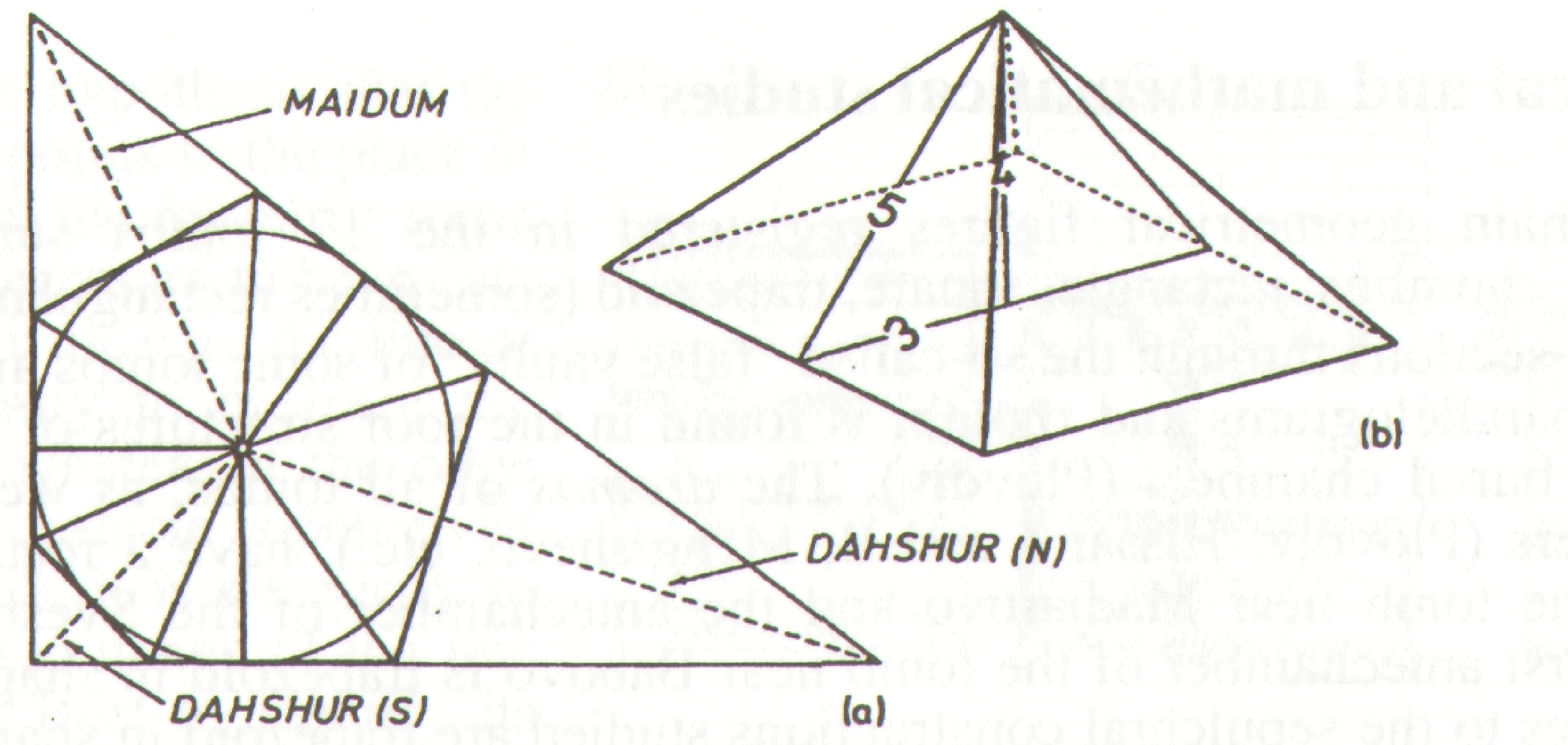


Figure 3. The design of pyramids in Egypt: (a) the triangle 3:4:5 and the three pyramids of Snofru; (b) meridian triangle in Chephren's pyramid.

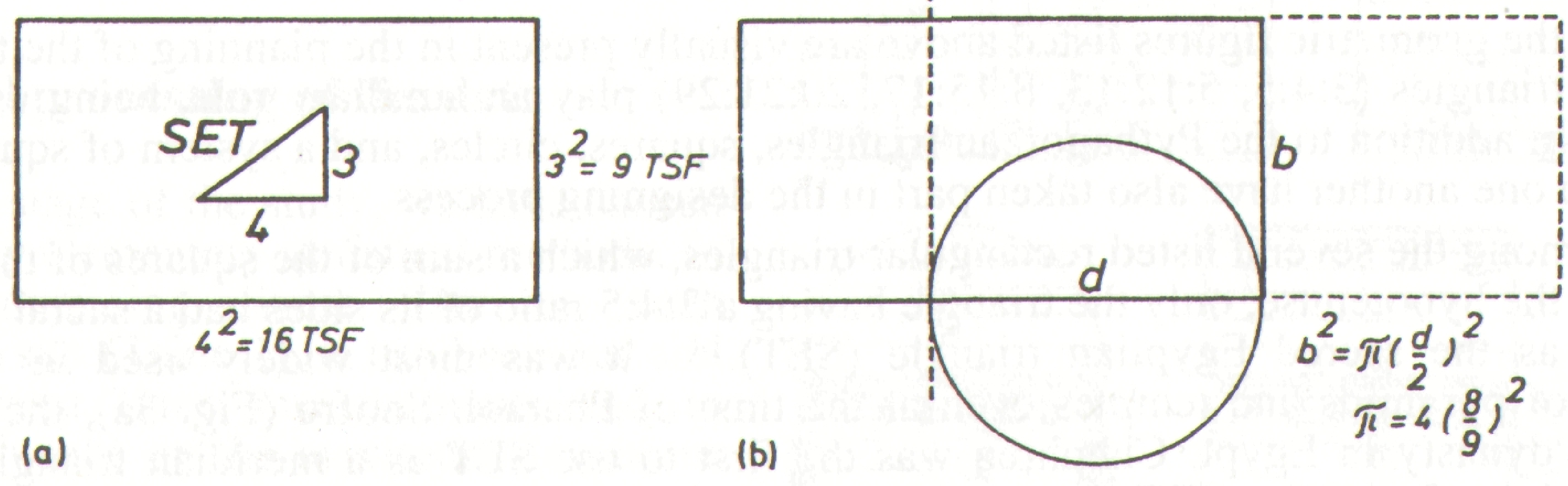


Figure 4. Design of a Thracian tomb near Sveshtary (Sveshtary I): (a) design of the inner rectangle; (b) design of the length of the burial chamber.

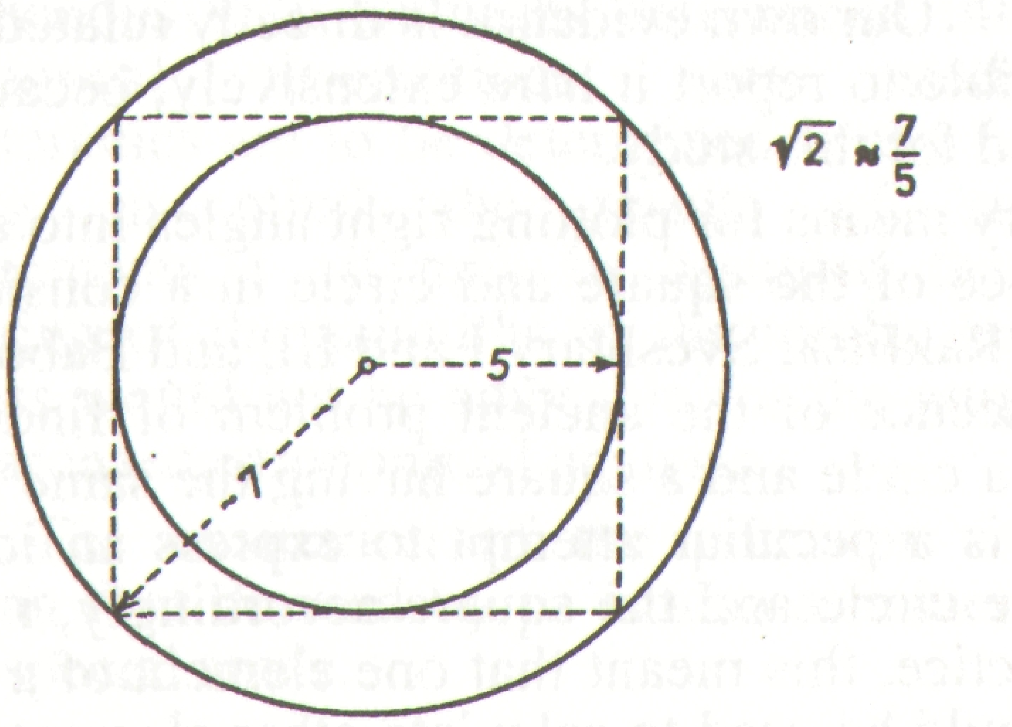


Figure 5. Design of the horizontal plan of the burial chamber of the Thracian tomb near Kazanluk.

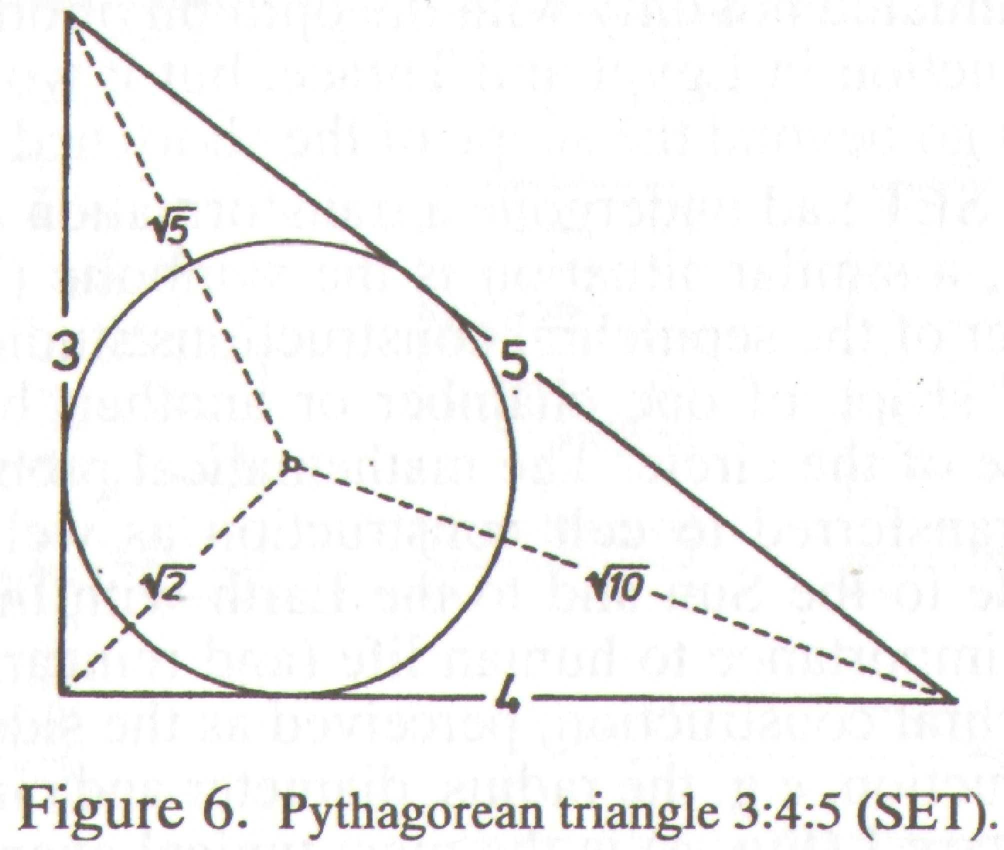


Figure 6. Pythagorean triangle 3:4:5 (SET).

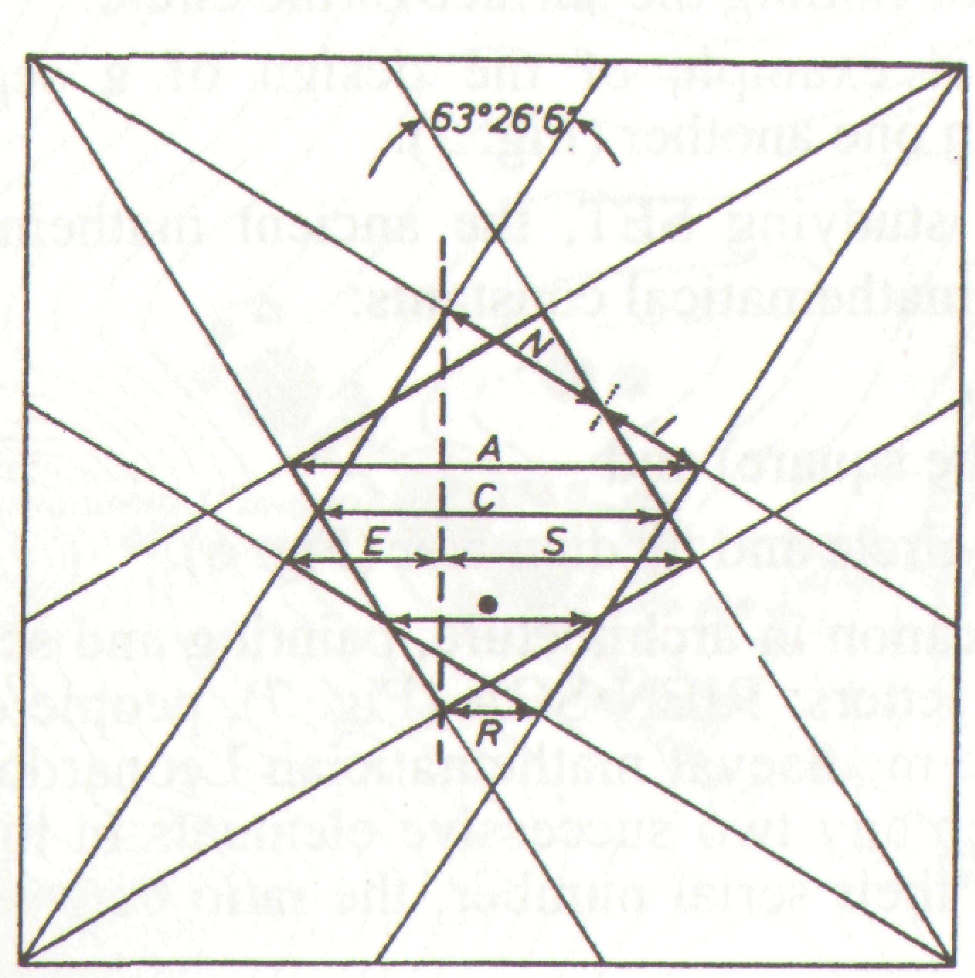


Figure 7. Plan of the starting figure of the ancient Egyptian canon RIEN•SCA.

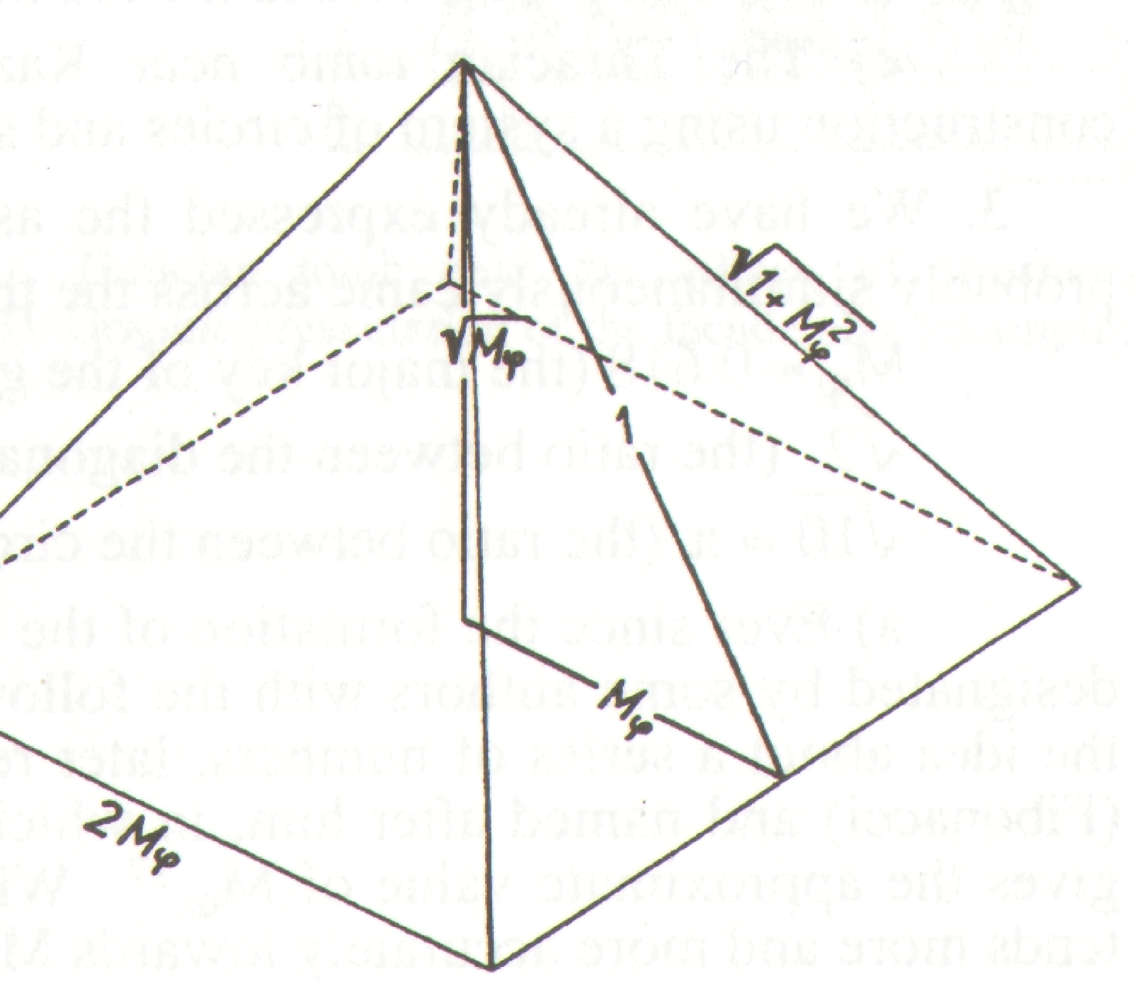


Figure 8. Basic elements of Snofru's first pyramid and of the Cheops pyramid.

segments. The biggest number in this series, presented in the design of a Thracian tomb, is the 17th element - 1597 (Ravnogor I), the longest series is discovered in the design of the tomb near Mengishevo (21, 34, 55, 89 and - without 144 - 233). Other tombs: Kurt-Kale (89 and 377), Hissar I (89), Kaliakra (89) Sveshtary I (34, 89 and 144), Sveshtary II (89 and 144), Babovo (55, 89 and 144). Tombs designed with the help of the golden proportion but without Fibonacci numbers are: Mezek I, Plovdiv and Kazanluk, whereas tombs designed without the golden proportion and without Fibonacci numbers are: Madjarovo, Raklitsa, Ravnogor II, Strelcha, Hissar II and Sveshtary III.

Here it is necessary to mention something else as well. The design of the tombs Mezek I, Ravnogor I, Plovdiv, Hissar I, Sveshtary II and Babovo comprises the meridian triangle of Snofru's first pyramid, the one in Maidum, and of the Cheops pyramid in Giza. The elements of the meridian triangle are: M_φ, $\sqrt{M_\varphi}$ and 1, but they are most frequently present as the side of a square base, equal to $2M_\varphi$, and the inclined edge $\sqrt{1+M_\varphi^2}$ (Fig. 8). The following approximations were used in the design of the pyramids:

$$M_\varphi = 21/34,\quad \sqrt{M_\varphi} = 11/14,\quad 2M_\varphi = 21/17,\quad \sqrt{1+M_\varphi^2} = 20/17,$$

$$(1 + M_\varphi)/2M_\varphi = 17/13.$$

b) Geometric constructs with $\sqrt{2}$ were found in the designs of the tombs near Kurt-Kale, Ravnogor I, Sveshtary II and Babovo. Most frequently, $\sqrt{2}$ is multiplied by the side of the square chamber and is "straightened up" in order to fix the height of the chamber (Sveshtary II),[18] or is "turned" in the horizontal plane in order to give the length of the chamber (Kurt-Kale). This technique of rotation has been accepted for rectangular figures as well for determining the thickness of the dividing walls Kazanluk and Sveshtary II).

The approximations most frequently used for $\sqrt{2}$ are: 7/5, 10/7 (Kazanluk), 17/12 (Sveshtary II) and 24/17 (Babovo; the Parthenon).[19]

c) The three mathematical constants mentioned in the beginning of item 3 above are irrational numbers. But while equations can be derived and solved for the first two, where $M_\varphi = (\sqrt{5} - 1) / 2$, and $\sqrt{2} = d/a$, where *a* is the side and *d* is the side and *d* is the diagonal of the square, i.e. M_φ and $\sqrt{2}$ can be plotted geometrically, π is a transcendental number and hence it cannot be plotted. Consequently, there are some insoluble problems connected with the number π, inherited from ancient times. We have already considered the application of the problem of finding the surface of the circle in designing tombs. The study of the 17 tombs showed a case when one linear element is perceived as the radius of a circle whose perimeter has been transformed into another linear element. Such cases have been registered in the designs of the tombs at Ravnogor II and Mengishevo (Fig. 9).

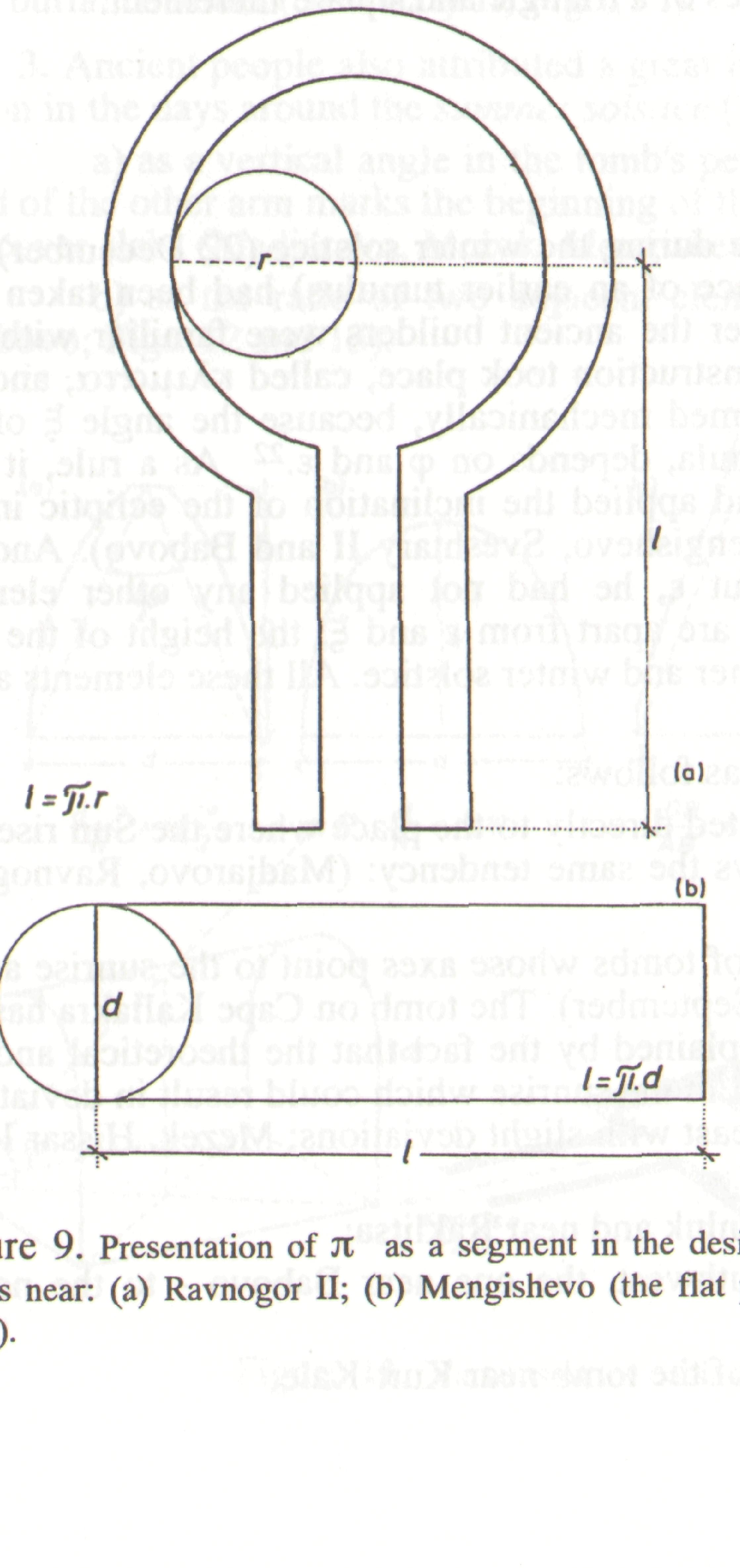


Figure 9. Presentation of π as a segment in the designs of the tombs near: (a) Ravnogor II; (b) Mengishevo (the flat part of the vault).

The most frequently used approximations for π are: $\sqrt{10}$ = 19/6, $4(8/9)^2$ and 22/7.

4. The historical-mathematical investigation of the designs of the 17 Thracian tombs yielded other interesting results as well:

a) The use of the perfect numbers 6, 28 and 496 (Kurt-Kale), 6 and 28 (Hissar I, Sveshtary II) and only 6 (Kazanluk);[20]

b) The use of numbers raised to a certain power (independently or in a ratio with other numbers: 7, 7^2, 7^3, 7^4 and 7^5 (Mezek), 3:4 and $3^2:4^2$ (Plovdiv, Sveshtary I), 6 and 6^3 (Kazanluk);

c) The use of numerical inversions: 12 and 21, accordingly $12^2 = 144$ and $21^2 = 441$ (Plovdiv), 3^6 and 6^3 (Kazanluk);

d) With the exception of the tombs Strelcha, Hissar II and Sveshtary III, the remaining tomb designs contain numbers which may be referred to as "cosmic" and for which a special preference was noted: 3 and 33; 7, 17, 27 and 77; 10. The most frequently used number from the Fibonacci series was 89;

e) The design which we are to examine in the greatest detail started from a square having the following sides: 12 (two cases), $\sqrt{233}$ (Mengishevo), 17 (three cases), approx. 20, 21 (two cases), $\sqrt{466}$ (Kurt-Kale: 377+89 = 466), 27, 33 (two cases), 36 (two cases) and 49 (Mezek). The design started simultaneously with two squares only in two cases: Plovdiv (12 and 21) and Sveshtary I (12 and 17). Smaller squares were used for designing the interior space of the tombs.

For lack of sufficient information about the tombs Strelcha, Hissar II and Sveshtary III, we have not yet found out the dimensions of the squares on which their design was based.

There is a hypothesis that the first theorems formulated by the ancient mathematicians were demonstrated by folding and superimposing of figures, by cutting a figure into parts and by covering it with another figure.[21] This means that geometric proof involved the component of movement. We failed to discover the latter component in the designs of only four tombs: Madjarovo, Hissar II, Kaliakra and Sveshtary III. In the remaining 13 tombs we identified the following "movements" in the course of the design process: rolling (unfolding of a circle), raising (of the diagonal of a horizontal figure), folding and raising, proportional increment, straightening up of the sides of a triangle and square increment.

III. Historical and astronomical studies

The orientation of the Sveshtary tomb towards the sunrise during the winter solstice (22 December) and especially the fact that the artificial obstacle (the existence of an earlier tumulus) had been taken into account and overcome, has prompted us to check whether the ancient builders were familiar with and applied the geographic latitude of the place where the construction took place, called κλιματα, and the inclination of the ecliptic ε. This verification was performed mechanically, because the angle ξ of the sunrise (and sunset), according to the contemporary formula, depends on φ and ε.[22] As a rule, it was found that in all cases when the ancient builder knew and applied the inclination of the ecliptic in the design process, i.e. *tg*φ (Madjarovo, Mezek, Hissar I, Mengishevo, Sveshtary II and Babovo). Another observation: if the builder knew and applied φ without ε, he had not applied any other element characteristic of the visible movement of the Sun. These are apart from ε and ξ, the height of the Sun during the spring and autumn equinox, as well as the summer and winter solstice. All these elements are given in Fig. 8.

1. *The orientation* of the 17 Thracian tombs studied is as follows:

a) Only the Sveshtary tomb (Sveshtary II) is oriented directly to the place where the Sun rises on December 22, but the orientation of six other tombs shows the same tendency: (Madjarovo, Ravnogor I and II, Strelcha, Sveshtary I and III) - a total of 7 tombs;

b) The next group according to numbers consists of tombs whose axes point to the sunrise at the time of the spring and autumn equinox (21 March and 23 September). The tomb on Cape Kaliakra has the most precise orientation to the east. This can easily be explained by the fact that the theoretical and the visible horizon practically blend there, i.e. there is no delay in the sunrise which could result in deviations to the south. Another four tombs are oriented towards the east with slight deviations: Mezek, Hissar I and II, and Mengishevo - a total of 5 tombs;

c) Two tombs have a southern orientation: in Kazanluk and near Raklitsa;

d) The tomb near Plovdiv is oriented to the southwest, the one near Babovo - to the north-northeast;

e) We lack information only about the orientation of the tomb near Kurt-Kale.

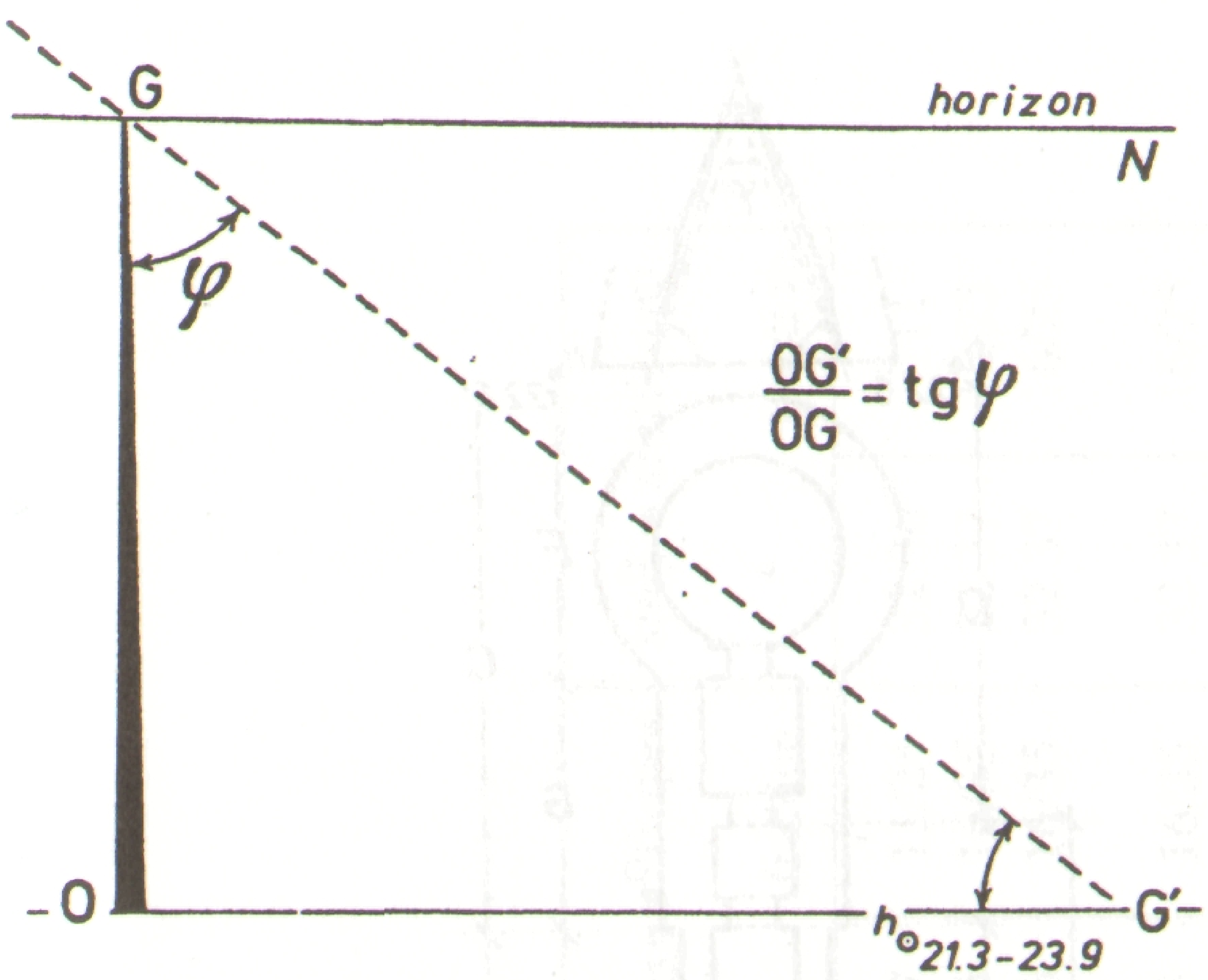


Figure 10. Gnomonic measurements of the geographic latitude.

2. Knowledge about the *geographic latitude* φ (κλιματα) was an important prerequisite for making time-measuring devices - sundials. In fact, it was necessary to know the ratio between the height of one gnomon and the shadow it casts at noon on the day of the spring or autumn equinox (Fig. 10).

The inclination of the sky was represented as the ratio of integers (Table 2). This means that it could have been coded using two adjacent linear elements in the sepulchral constructions, these two linear elements being usually located in the burial chamber. Six variants can be distinguished:

a) φ is symbolically present in the vault (Madjarovo, Mezek, Plovdiv and Mengishevo; Fig. 11a);

b) *tg*φ is obtained as the ratio between the height and the width of the burial chamber (Raklitsa and Babovo; Figs. 11b and 12);

c) *tg*φ equals the ratio between the height of the burial chamber and the distance from its periphery to the centre of the vault (Kurt-Kale, Kazanluk; Fig. 11c);

d) φ is located in the periphery of the burial chamber, at the level of the floor. In that case one of the arms is pointing to the Polaris (Hissar I; Fig. 11d);

e) φ is between the diagonal and the side, at the level of the floor of the burial chamber (Sveshtary II; Fig. 11e);

f) *tg*φ is accepted as the coefficient for proportioning two adjacent elements in the vertical plan of the burial chamber (Sveshtary II; Fig. 11 f).

3. Ancient people also attributed a great importance to the *height of the Sun* during its culmination at noon in the days around the *summer solstice* (22 June). It was coded in two ways:

a) as a vertical angle in the tomb's periphery: one arm is lying on the plane at the floor level, the end of the other arm marks the beginning of the horizontal part of the vault - the round lid or the rectangle of cover slabs (Madjarovo, Mezek, Mengishevo; Fig. 12);

b) as the ratio of two adjacent elements, e.g. the lengths of two adjacent chambers (Mezek, Babovo; Figs. 12 and 13).

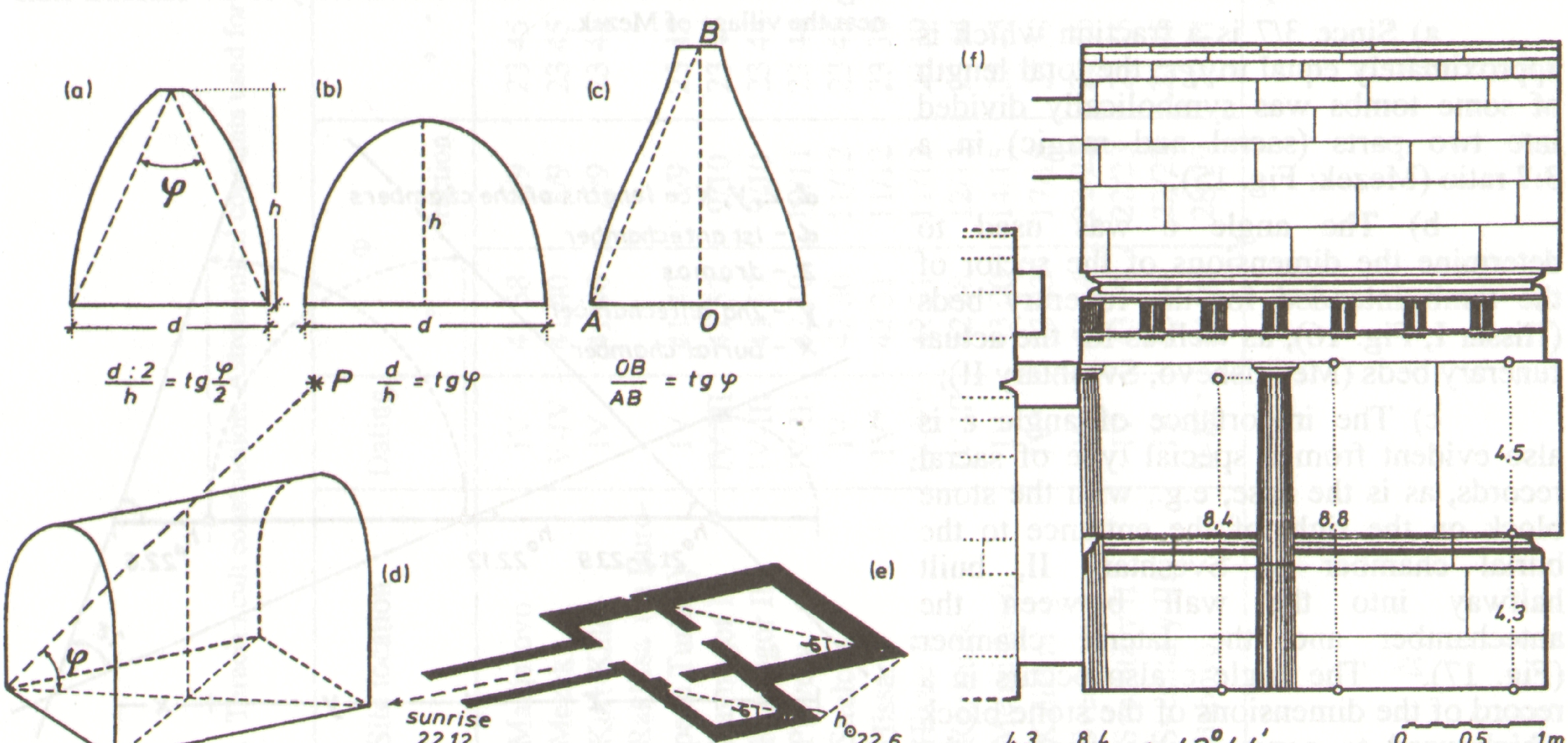


Figure 11. Variants of the coding of the geographic latitude φ in the burial chambers.

4. The *height of the Sun* when it culminates at noon on the day of the *spring and autumn equinox* is represented as follows:

a) as a vertical angle with one arm lying on the plane of the floor level, while the other arm marks the upper threshold of an entrance (Mengishevo), the apex of a vault (Hissar I), etc.;

b) since $h_{o21.3\text{-}23.9} = 90° - \varphi$, the ways in which φ, was coded are identical to those described in 2 b, c, d, e, f and demonstrated on Figs. 11b, c, d, e, f, 12 and 13.

5. The *height of the Sun* at noon in the days around the *winter solstice* is used for designing tombs so that:

a) one arm lies in the plane at the level of the floor, the other one marks the lower threshold (Mengishevo) or the upper threshold of the entrance to the burial chamber (Madjarovo), the beginning of the vaulting (Mengishevo) or the apex of the vault (Hissar I);

b) the ratio of two adjacent elements, e.g. the lengths of two adjacent chambers, to equal $tgh_{o22.12}$ (Mezek, Babovo; Figs. 12 and 13).

6. *The inclination of the ecliptic*, accepted by Vitruvius to be equal to 24°, is a parameter which can be measured and represented as the ratio between two segments (Fig. 14).

It is interesting to note that the angle ε was used on more special occasions:

a) Since 3/7 is a fraction which is approximately equal to *tg*ε, the total length of some tombs was symbolically divided into two parts (sacral and magic) in a 3:7 ratio (Mezek; Fig. 15);

b) The angle ε was used to determine the dimensions of the sector of the tomb intended for the funerary beds (Hissar I; Fig. 16), as well as for the actual funerary beds (Mengishevo, Sveshtary II);

c) The importance of angle ε is also evident from a special type of sacral records, as is the case, e.g., with the stone block on the right of the entrance to the burial chamber of Sveshtary II, built halfway into the wall between the antechamber and the lateral chamber (Fig. 17).[23] The angle ε also occurs in a record of the dimensions of the stone block which used to serve as the door to the burial chamber of the tomb near Babovo (Fig. 18).

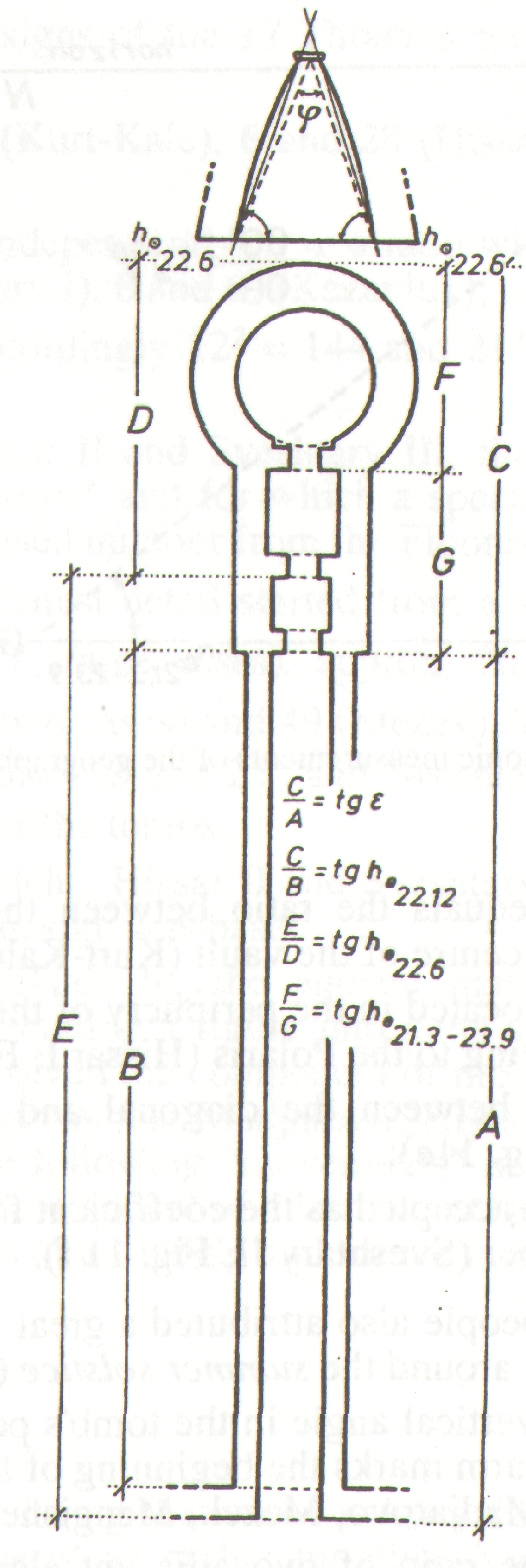


Figure 12. Historical and astronomical study of the Thracian tomb near the village of Mezek.

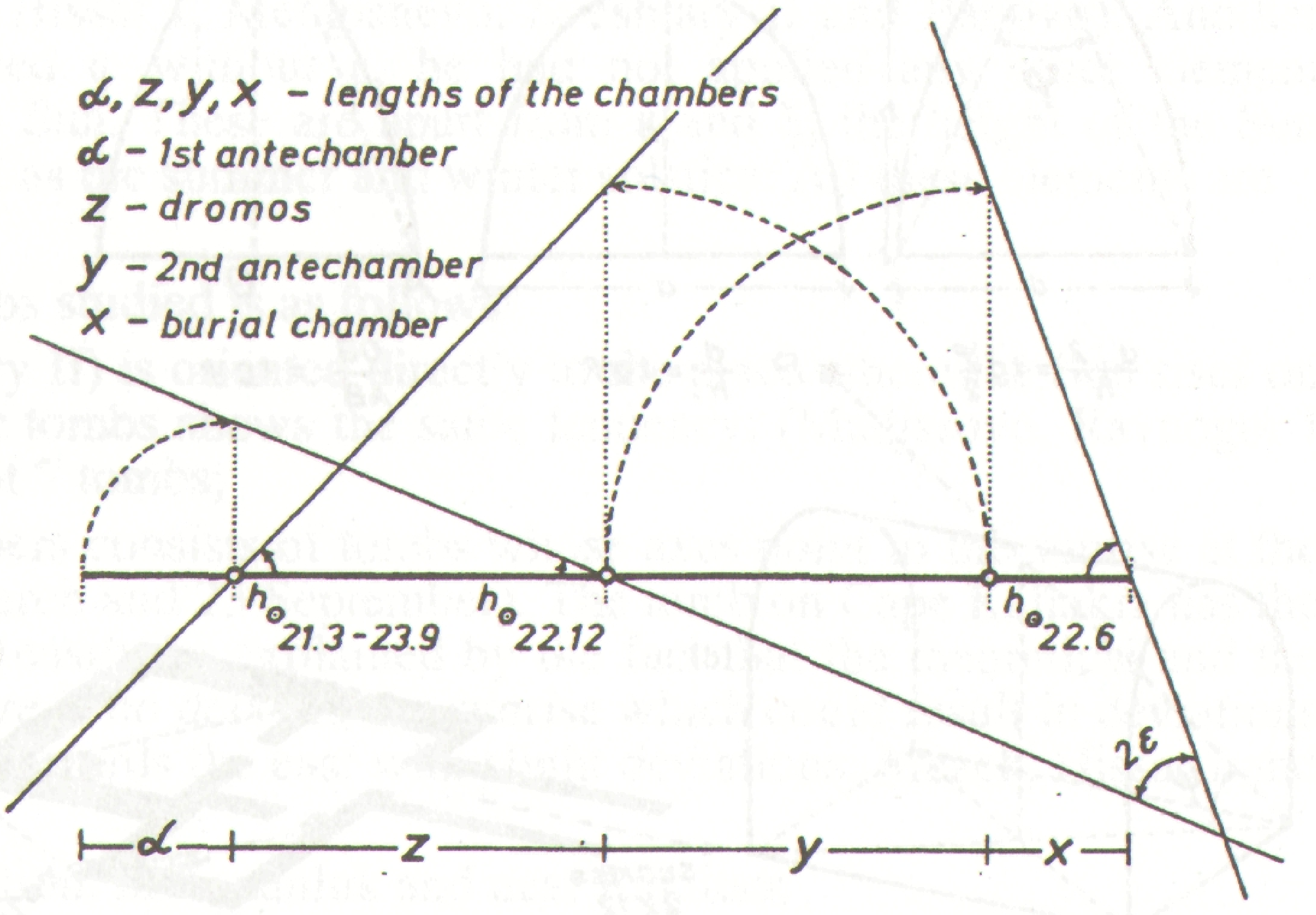


Figure 13. Historical and astronomical study of the ancient tomb near the village of Babovo.

Table 2. Thracian cult construction. Astronomical constants used for designing tombs.

1	Site location	Dating	φ		ε		$h_{o21.3\text{-}23.9} = 90-\varphi$		$h_{o21.3\text{-}23.9} = 90-\varphi+\varepsilon$		$h_{o21.3\text{-}23.9} = 90-\varphi-\varepsilon$		$\sin\xi = \sin\varepsilon/\cos\varphi$	
			° ′	fraction	° ′	fraction	° ′	fraction	° ′	fraction	° ′	fraction	° ′	fraction
1	Madjarovo	IV	41 38	8/9	23 45	11/25	48 22	9/8	72 07	34/11	24 37	11/24	32 36	7/11
2	Mezek	V-IV	41 40	8/9	23 45	11/25	48 20	9/8	72 05	34/11	24 35	16/35	32 37	16/25
3	Kurt-Kale	IV	41 40	8/9	23 45	11/25	48 20	9/8	72 05	34/11	24 35	16/35	32 37	16/25
4	Raklitsa (in European Turkey)	IV	41 40	8/9	23 45	11/25	48 20	9/8	72 05	34/11	24 35	16/35	32 37	16/25
5	Ravnogor I	IV-III	41 57	9/10	23 44	11/25	48 03	10/9	71 47	~3	24 19	9/20	32 46	16/25
6	Ravnogor II	IV-III	41 57	9/10	23 44	11/25	48 03	10/9	71 47	~3	24 19	9/20	32 46	9/14
7	Plovdiv	IV-III	42 10	10/11	23 44	11/25	47 50	11/10	71 34	3	24 06	4/9	32 53	9/14
8	Strelcha	IV	42 30	11/12	23 45	11/25	47 30	12/11	71 15	53/18	23 45	11/25	33 07	2/3
9	Hissar I	IV*	42 31	11/12	23 39	7/16	47 29	12/11	71 08	29/10	23 50	11/25	32 59	2/3
10	Hissar II	IV-V*	42 31	11/12	23 39	7/16	47 29	12/11	71 08	29/10	23 50	11/25	32 59	2/3
11	Kazanluk	IV-III	42 38	12/13	23 44	11/25	47 22	13/12	71 06	29/10	23 38	7/16	33 10	2/3
12	Mengishevo	IV	43 00	14/15	23 45	11/25	47 00	15/14	70 45	20/7	23 15	3/7	33 25	2/3
13	Kaliakra	IV*	43 23	17/18	23 39	7/16	46 37	18/17	70 16	14/5	22 58	3/7	33 30	2/3
14	Sveshtary I	IV	43 44	22/23	23 45	11/25	46 16	23/22	70 00	11/4	22 32	5/12	33 52	2/3
15	Sveshtary II	IV	43 44	22/23	23 45	11/25	46 16	23/22	70 00	11/4	22 32	5/12	33 52	2/3
16	Sveshtary III	IV	43 44	22/23	23 45	11/25	46 16	23/22	70 00	11/4	22 32	5/12	33 52	2/3
17	Babovo	II-III*	44 00	28/29	23 41	7/16	46 00	29/28	69 41	27/10	22 19	7/17	33 57	2/3

*AD

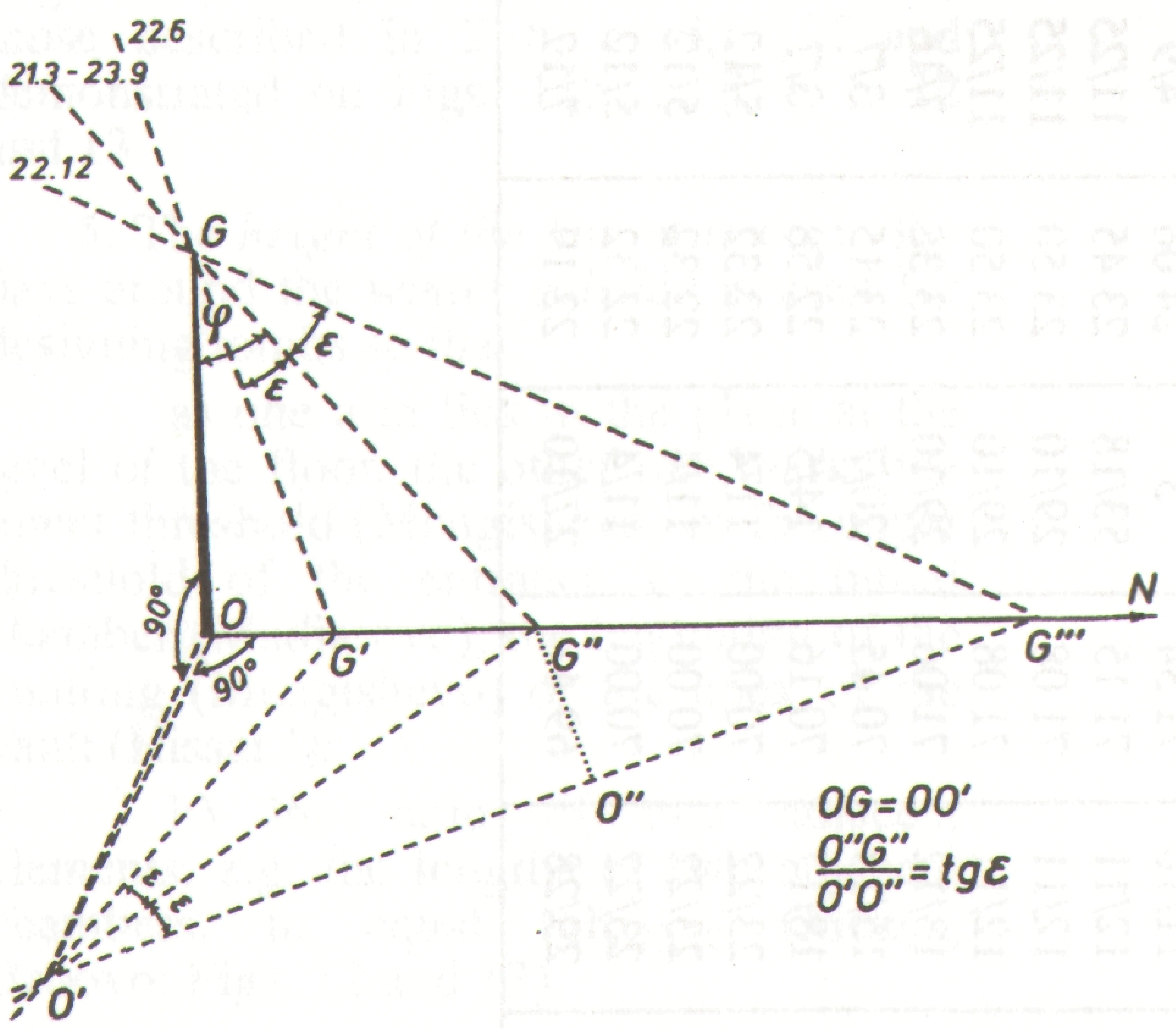


Figure 14. Measuring of the inclination of the ecliptic ε and presentation of *tg*ε.

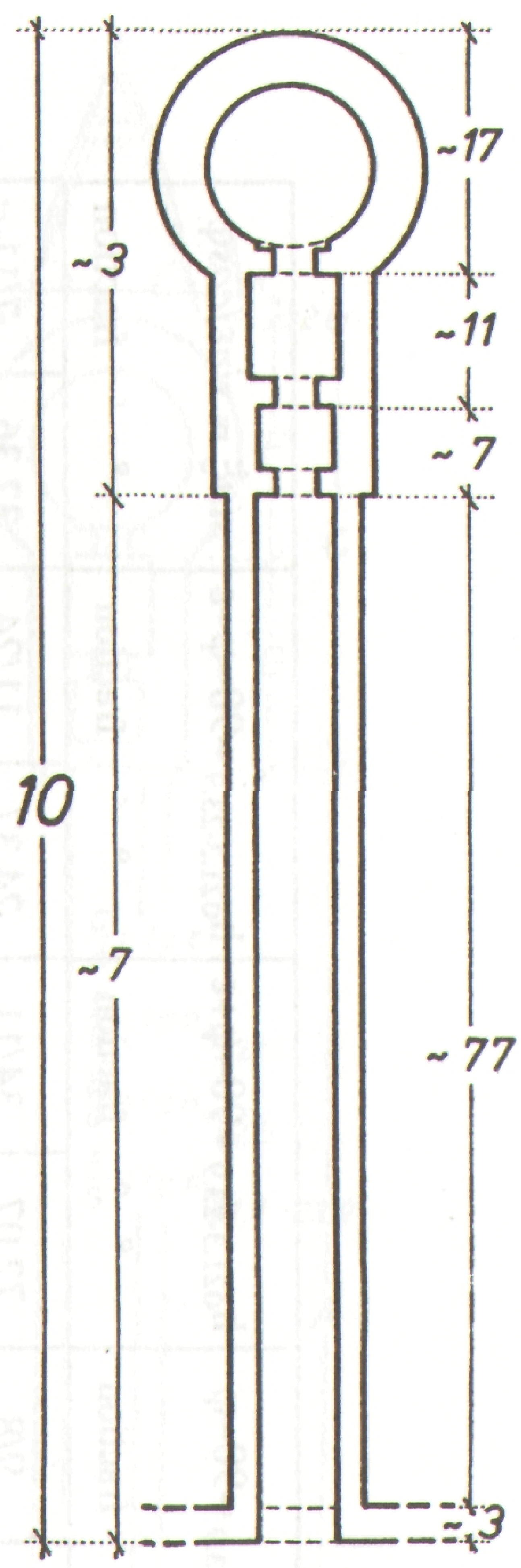


Figure 15. Historical and mathematical study of the tomb near the village of Mezek.

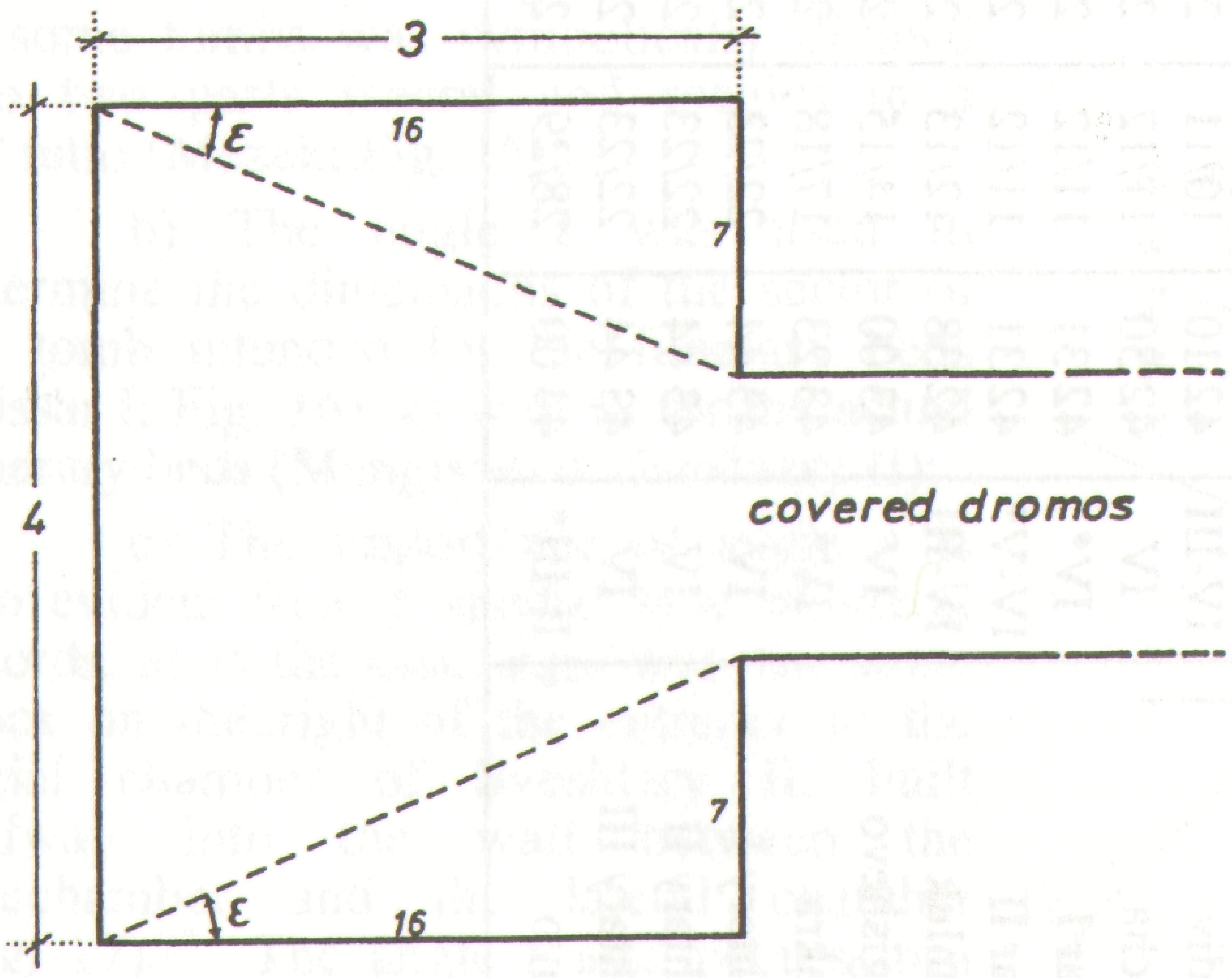


Figure 16. Historical and astronomical study of the ancient tomb near the town of Hissar (Hissar II).

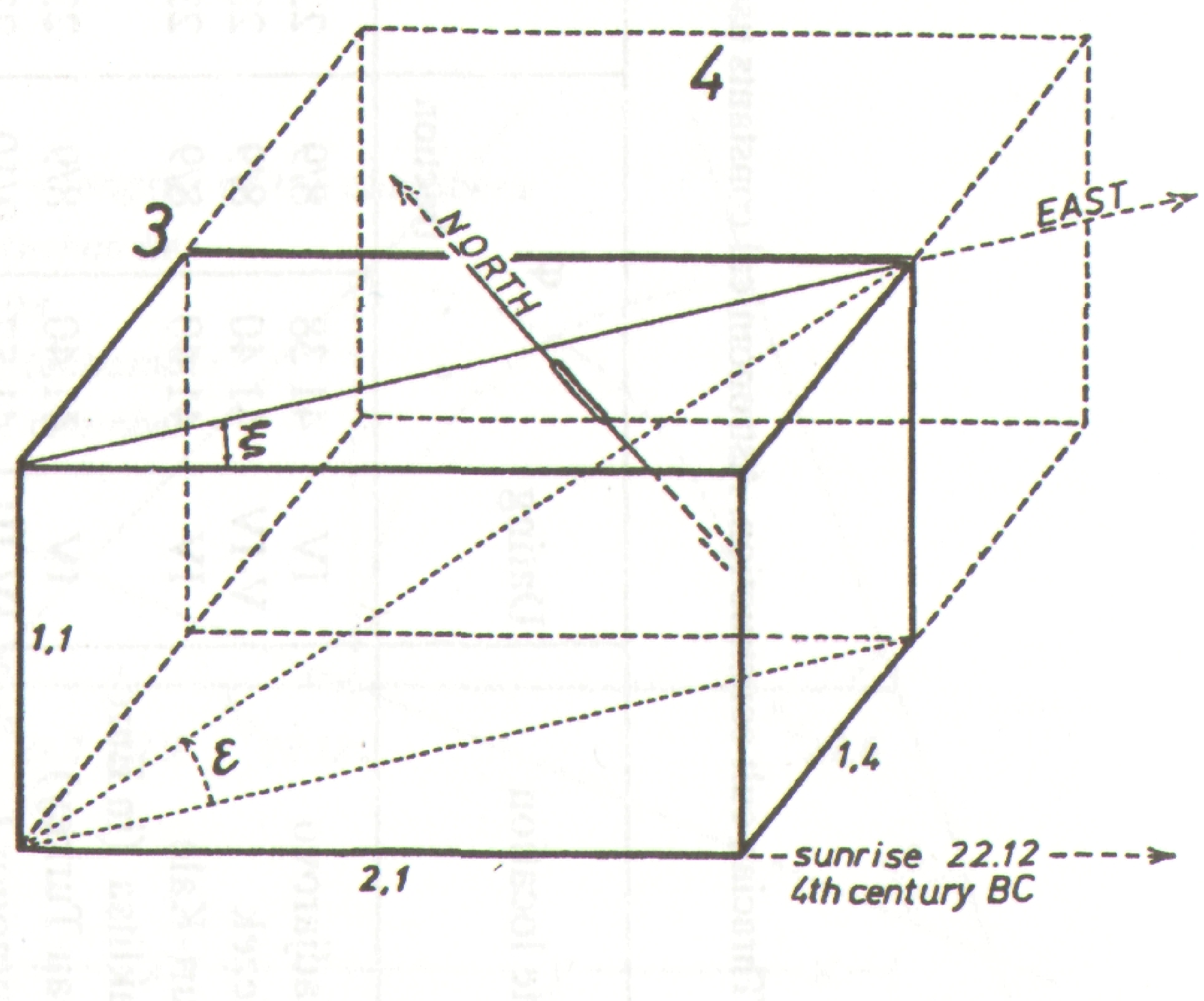


Figure 17. Archaeoastronomical study of a stone block of a cult nature from the Thracian tomb near the village of Sveshtary (Sveshtary II).

7. The last angle characterizing the visible motion of the Sun, and more specifically its tangents, which was used for determining the dimensions of sepulchral constructions in the lands of the Thracians, was *the angle* ξ - *between the east-west line and the sunrises/sunsets during the summer and winter solstices* (Fig. 19). The angles ε and ξ are similar, not in value (Table 2), but as parameters defining the two extreme positions of the Sun in the meridian and horizontal planes during the solstices (Fig. 19).

a) With the awareness of this similarity, the ancient builders included them simultaneously in the same records (Figs. 17 and 18);

b) The angle ξ was used to determine the dimensions of the external rectangular projection plane (Fig. 20);

c) The angle ξ was used for designing details (Fig. 21).

It is important to note that while angle ε appeared both in a horizontal and in a vertical plan, angle ξ was applied always in a horizontal plan.

8. It would be logical to assume that the ancient creators of the most impressive tombs also recorded *calendar systems* in addition to the mathematical and astronomical constants. Two techniques were used:

a) Design and execution of linear and planar architectural elements (Mezek, Kurt-Kale, Raklitsa);

b) Combination of architectural and sculptural details (Sveshtary II).

The problem raised here, however, requires a special study. Evidence in this respect can be found in several monuments from Egypt (not counting the numerous calendar records on sarcophagi) and from classical Greece (the Parthenon).

IV. The Thracian sacred foot (TSF)

The question of the existence of a Thracian measuring unit was raised for the first time by D.Vasileva.[24] The size of the Thracian foot measured by her is 0.29 m. We are not disputing this result of her many years of research. Perhaps some Thracian monuments were again measured in terms of a linear unit equal to 0.29 m. It would be quite logical to assume that the measuring unit underwent at least several changes over a period of Thracian construction lasting about a thousand years, just as there were changes in the coinage as well.[25] Consequently, the second Thracian foot derived by us (0.2676 m) is also entitled to an existence of its own, for two main reasons:

a) The first reason is elementary: the ratio between the two feet 0.2676/0.29 equals approximately 12/13. Since $tg\varphi$ equals 12/13 for the region of Seuthopolis (see Table 2 - the geographic latitude φ of Kazanluk), it may be assumed that the idea about the ratio between the linear unit applied in civil construction (0.29 m) and the one applied in cult construction (0.2676 m) occurred in the course of gnomonic measurements during equinox: a gnomon with a height of 13 units casts a 12 units long shadow at noon (21 March and 23 September);[26]

b) The second reason is more essential, because the probability of a coincidence is practically nil. We have investigated 17 tombs, in only one of which (Hissar II) TSF was not used, but a Roman foot equal to 0.2959 m. The dimensions of two other tombs - Ravnogor I and II - were fixed using modules: 0.2226 m in Ravnogor I; 0.2226/0.2676 = 5/6 - and approx. 0.64 m in Ravnogor II; 0.6404/0.2676 $\approx$ 12/5. Consequently, 14 out of the 17 tombs explored allow TSF to be derived again; 1 TSF = 0.2676 m was obtained only from the metric data of the Sveshtary tomb.[27]

Since with the present study we would like to make yet another certain step towards establishing TSF in the specialized literature, we would like to present the following metric tests of the Late Antiquity tomb on Cape Kaliakra.

On Fig. 22a, b, c we have plotted the nine dimensions which are approximately divisible by the hypothetical measuring unit of 0.2676 m. The statistical method of the least squares, which is fundamental in geodesy, accepts this value to be equal to zero (s_0). Table 3, column 2 contains the dimensions s_i, which are the mean results of the repeated measurements of 9 details (column 1) shown on Fig. 22a, b, c. In column 3, against each dimension s_i we have calculated how many times (approximated to integer figures) the hypothetical measuring unit s_0 is contained, i.e. we have performed successive divisions $s_i/s_0 = s_i'$. In column 4 we have introduced with the maximum possible objectivity the weights of the measurements (according to a 6-grade system), taking into account not only the actual state of the details, but also their reliability in the beginning and in the end. For example, the distances from the level of the floor to the beginning of the cornice (1.056 m), from the floor to the upper rim of the cornice (1.205 m)

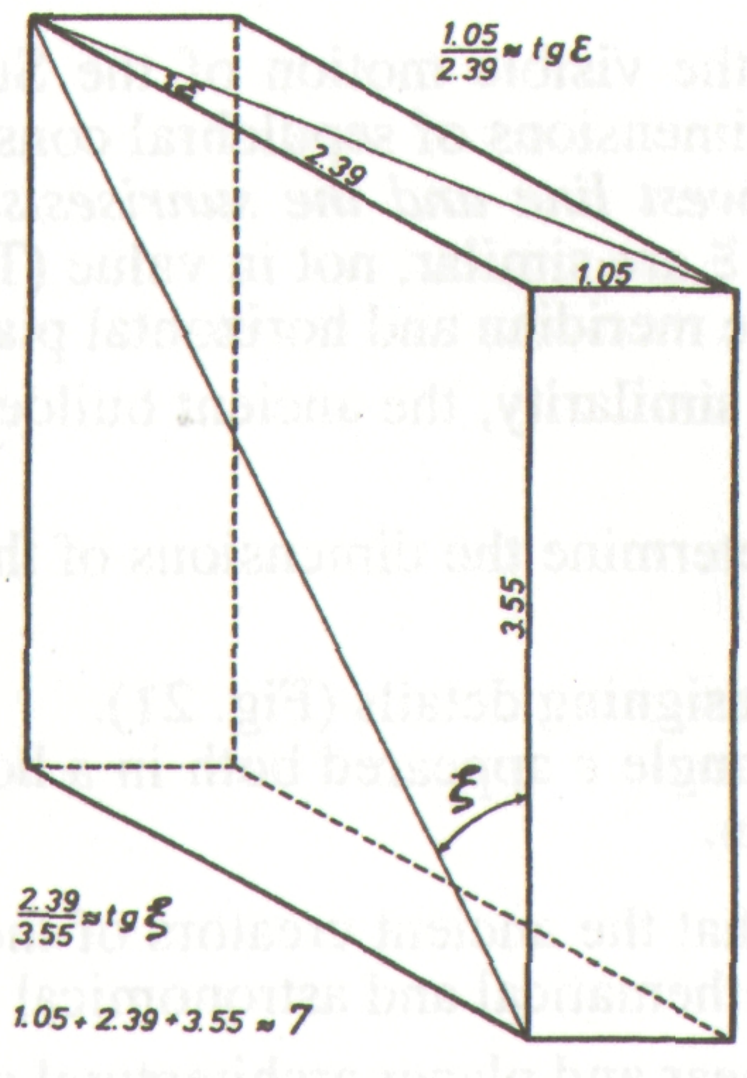


Figure 18. Archaeoastronomical study of a stone block from the ancient tomb near the village of Babovo (in Thracian feet).

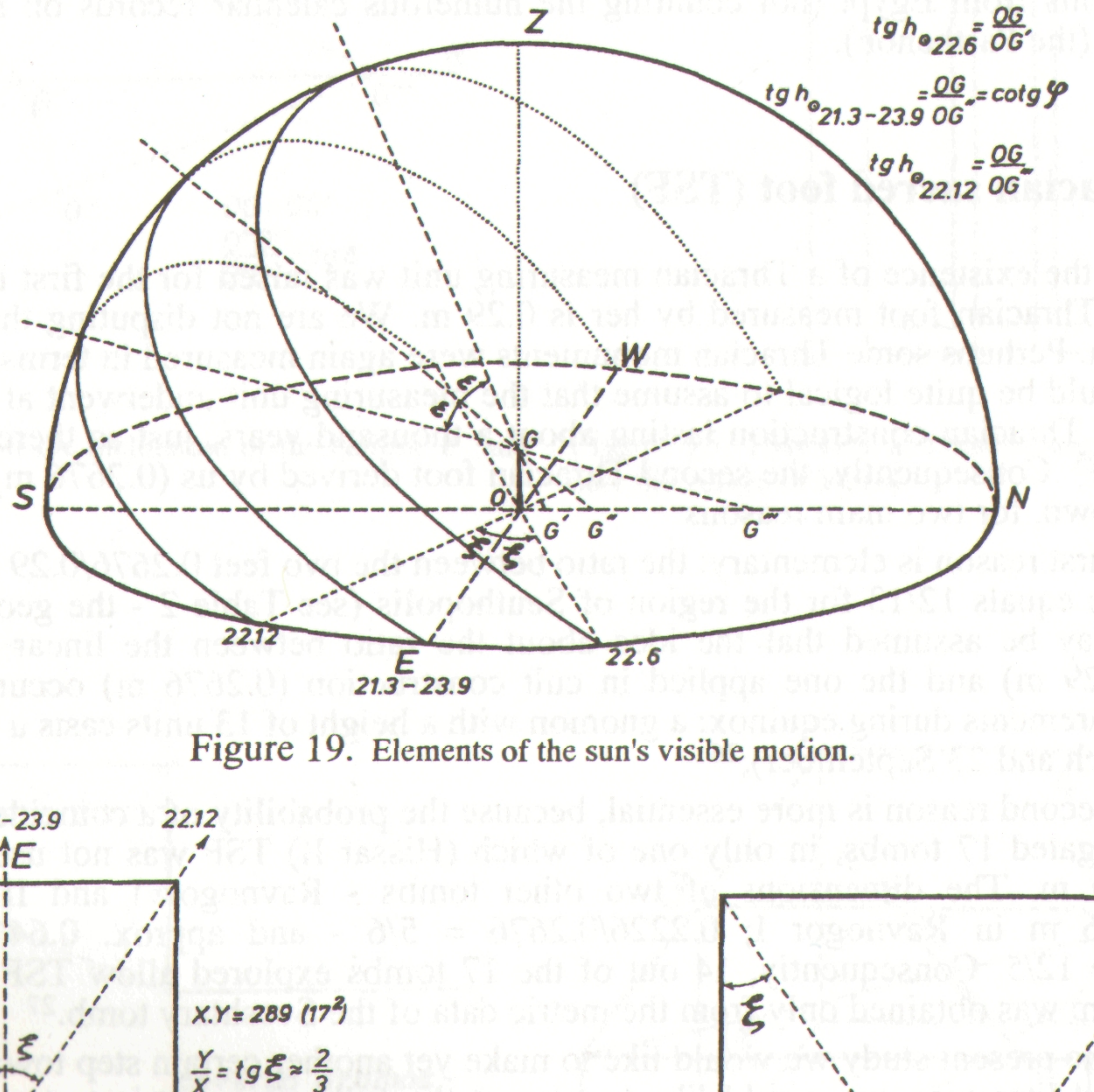


Figure 19. Elements of the sun's visible motion.

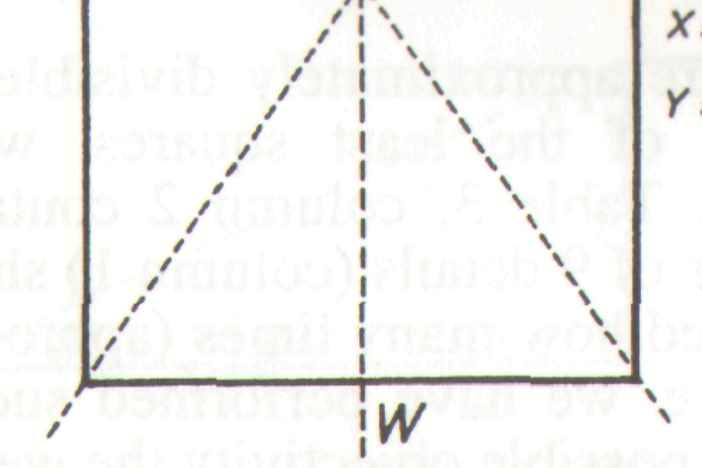


Figure 20. Archaeoastronomical study of the Late Antiquity tomb on Cape Kaliakra.

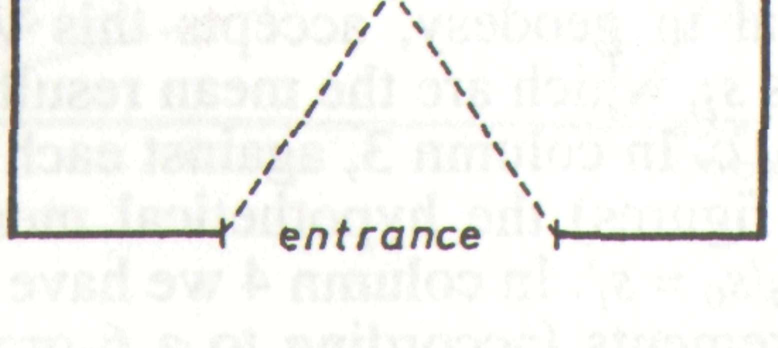


Figure 21. Historical and astronomical investigation of the Thracian tomb near the town of Madjarovo. Design of the entrance in horizontal plan.

Table 3. Late Antiquity tomb near Cape Kaliakra. Tabular records of some actual dimensions (with deriving of the measuring unit)

	Dimensions s_i according to:					
1	G. Kuzmanov	P. Valev*	s_i'	p_i	$s_i p_i$	$s_i' p_i$
1	2		3	4	5	6
1	-	2.715	10	6	16.290	60
2	3.20	3.209	12	6	19.254	72
3	2.68	2.678	10	6	16.068	60
4	2.40	2.410	9	4	9.640	36
5	0.80	0.798	3	6	4.788	18
6	1.10	1.056	4	4	4.224	16
7	1.30	1.205	4.5	4	4.820	18
8	0.85	1.062	4	3	3.186	12
9	1.20	1.330	5	3	3.990	15
		16.463	61.5	42	82.260	307

*$s_0 = 0.2676$ m, $s_i' = s_i / s_0$, $\sum s_i / \sum s_i' = 0.2677$, $\sum s_i p_i / \sum s_i' p_i = 0.2679$

and from the floor to the apex of the vault have been measured 8 times each, but as the level of the floor is not reliable, because twenty years have passed since the tomb was excavated (according to G.Kuzmanov, "the natural rock was used as the floor of the chamber, after it was smoothed, it was covered by a 2-3 cm thick layer of pink plaster"),[28] these three distances are given equal weight (4). Column 5 contains the values of $s_i.p_i$, column 6 - $s_i'.p_i$. Columns 2, 3, 4, 5 and 6 have been summed separately below. The ratios

$$\sum s_i / \sum s_i' = 16.463/61.5$$

$$\text{and } \sum s_i.p_i / \sum s_i'.p_i = 82.260/307$$

should result precisely in $s_0 = 0.2676$. After applying the mathematical operation division, we obtained two new values for TSF: 0.2677 and 0.2679 m. The results are within the anticipated limits of ± 0.0004 m.[29]

Parallel with the analysis of the problem related to the value of TSF, we would like to adduce arguments in support of the expediency of transforming the dimensions of Thracian cult monuments from the modern into the Thracian metric system for the purposes of archaeoastronomy.

1. First of all, it should be borne in mind that we do not have the precise values of the dimensions intended to be used by the ancient architect, making the difference between intended and designed values. The intended dimensions exist only conditionally in an ideal project, whereas the dimensions with which we operate are burdened with errors of a different nature:[30]

a) The ideal design is replaced by the

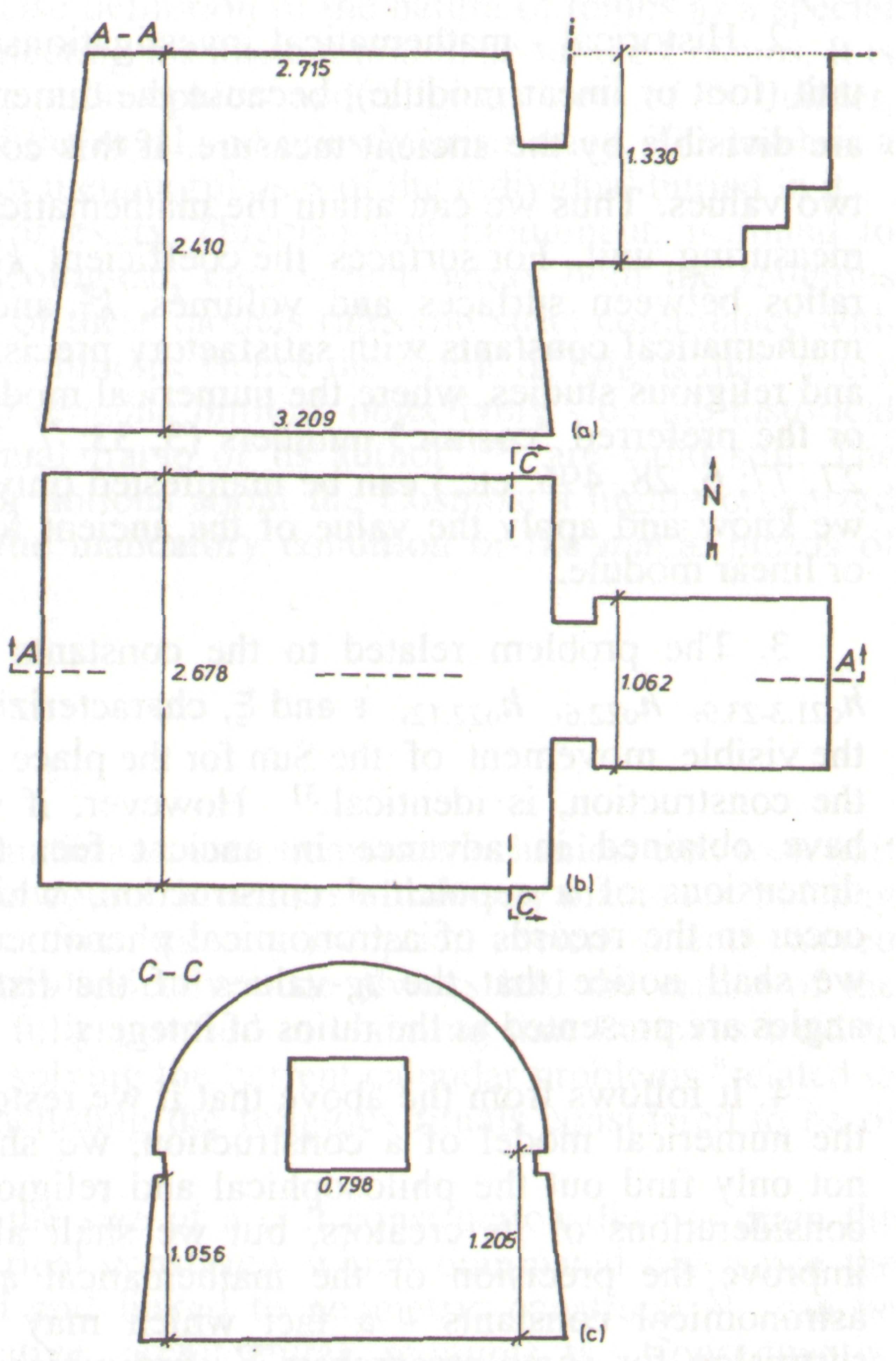


Figure 22. Metric investigation of the Late Antiquity tomb at Cape Kaliakra: (a) longitudinal section along the axis; (b) horizontal plan of the burial chamber and of the antechamber at the level of their floors; (c) cross-section of the burial chamber facing towards the entrance.

actual one, whereby considerable errors may result from the calculations or from the approximation introduced for the irrational values; particularly careful historical- mathematical research may establish what approximate values were accepted for M_φ, $\sqrt{2}$, π and other constants;

b) Errors which may be expected when the design is traced on the terrain;

c) Errors occurring in the course of construction;

d) Errors caused by the implementation of the design in stages;

e) Errors caused by the deformation of the construction, due to static mistakes in the design, to the fact that sound and good quality materials were not always used, to tilting of the buildings as a result of poor soils, fissures and twists caused by earthquakes;

f) Errors resulting from damage inflicted to the construction during plundering by treasure-hunters or as a result of poor preservation after the archaeological exploration;

g) Errors due to the incompetent intervention of restorers;

h) Errors in the contemporary measurements;

i) Errors resulting from the approximation of the results of the measurements (we calculate the different details with an accuracy of 0.01 TSF).

If we eliminate in the course of the study the gross and systematic errors, which are most frequently obvious and hence indisputable, only accidental errors will remain. According to the probability theory, their occurrence would tend to be 0, hence a modern study which takes into account everything stated so far on the possible errors and the level of knowledge in mathematics and astronomy, as well as the philosophical and religious dogmas of the society whose architectural cult monuments we are examining, could lead to findings of historical and academic interest.

2. Historical - mathematical investigations an be carried out even without knowing the measuring unit (foot or linear module), because the dimensions of a construction in contemporary measuring units are divisible by the ancient measure. If this coefficient is denoted by k, it can be cancelled by dividing two values. Thus we can attain the mathematical constants M_φ, $\sqrt{2}$, π, etc. without knowing the ancient measuring unit. For surfaces the coefficient k is obtained as k^2, for volumes - as k^3. If we examine the ratios between surfaces and volumes, k^2 and k^3 are also cancelled and we can obtain the coded mathematical constants with satisfactory precision. This is not the case, however, with the philosophical and religious studies, where the numerical models or the preferred "cosmic" numbers (3, 33; 7, 17, 27, 77; 6, 28, 496, etc.) can be manifested only if we know and apply the value of the ancient foot or linear module.

3. The problem related to the constants φ, $h_{o21.3\text{-}23.9}$, $h_{o22.6}$, $h_{o22.12}$, ε and ξ, characterizing the visible movement of the Sun for the place of the construction, is identical.[31] However, if we have obtained in advance in ancient feet the dimensions of a sepulchral construction, which occur in the records of astronomical phenomena, we shall notice that the *tg*-values of the listed angles are presented as the ratios of integers.

4. It follows from the above that if we restore the numerical model of a construction, we shall not only find out the philosophical and religious considerations of its creators, but we shall also improve the precision of the mathematical and astronomical constants - a fact which may be surprising for some researchers,[32] but which is axiomatic for us. We shall support our arguments with an example from the initial design stage of the Sveshtary tomb (Sveshtary II).

The side of the designed square is 33 TSF, its surface being 1089 square feet (Fig. 23).

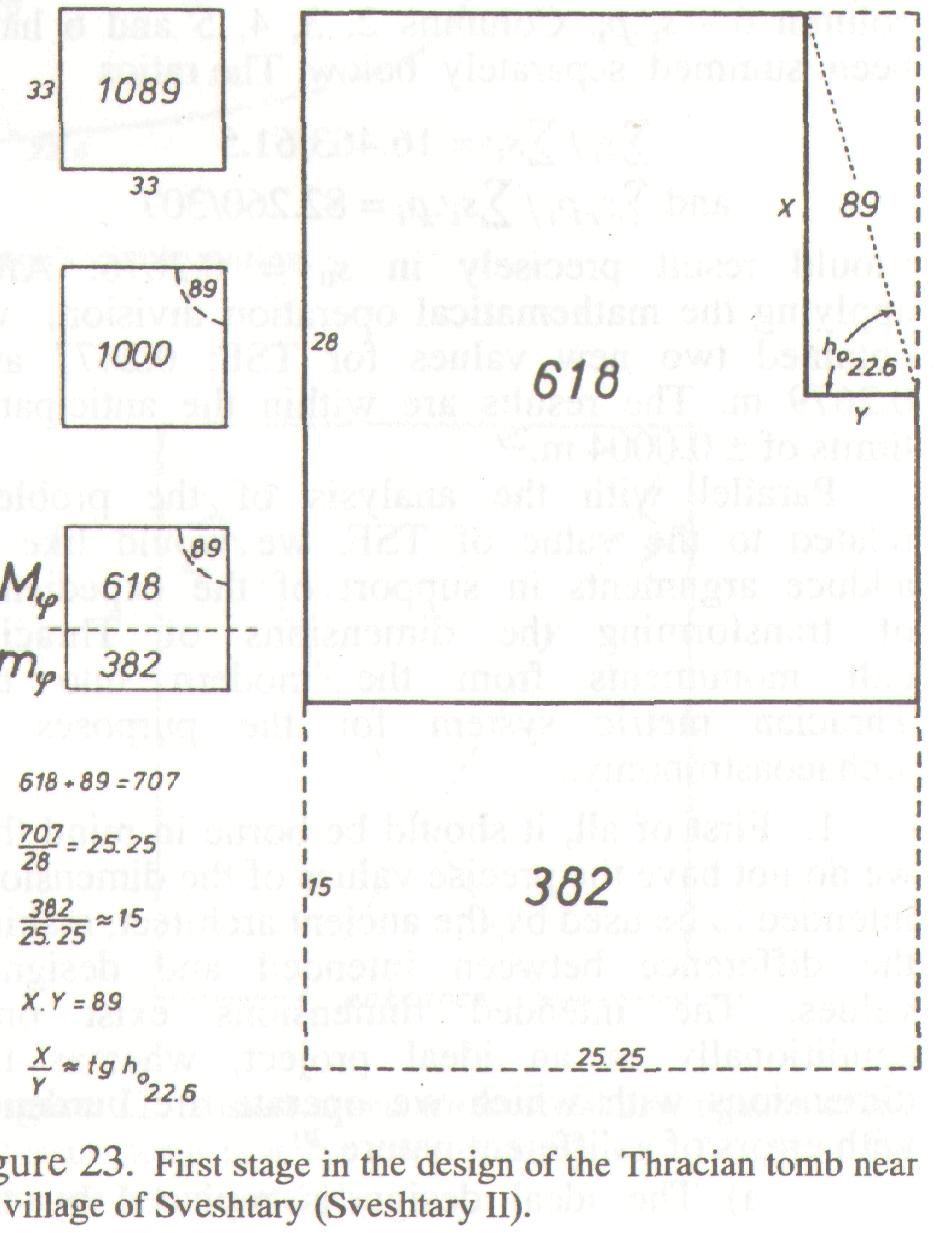


Figure 23. First stage in the design of the Thracian tomb near the village of Sveshtary (Sveshtary II).

The architect of the tomb set aside the area of 89 square feet as a symbol of chaos and did not build on it. The number 1000 is actually a big unit which he divided into a major part of 618 square feet for the tomb and a minor part of 382 square feet for the dromos. Then he divided the sum of 618 + 89 = 707 square feet by the perfect number 28, probably prompted by some motivation, and obtained the width of the tomb. During the second stage he used SET to determine the dimensions of the tomb's interior. All combinations with the sides of the SET are as follows:

3 - width of the lower threshold of the entrance to the lateral chamber;
4 - width of the lower threshold of the entrance to the main burial chamber;
5 - width of the lower threshold of the entrance to the antechamber (the main entrance;
3 + 4 = 7 - width of the dromos;
3 + 5 = 8 - side of the square lateral chamber;
4 + 5 = 9 - side of the square antechamber;
3 + 4 + 5 = 12 - side of the square burial chamber.

During the third stage, the architect of the tomb introduced astronomical constants, thus changing slightly the outlines of some of the chambers. The heights of the chambers were obtained by raising their diagonals, etc.

Researchers today are "following" the thoughts of the ancient builder through mathematical constructions and astronomical constants, with the help of the Thracian measuring unit.

V. The tombs as a special type of cult monuments

One of the main tasks of our study is to give a more precise definition of the nature of tombs as a special type of cult monuments.The tomb is a cult monument reflecting the ancient notion about the Cosmos. It is the perfect microcosm and a material manifestation of the philosophical and religious ideas of the builder, behind whom one should perceive the powerful figure of the royal and priestly aristocracy. The tomb is a sacral magic construction intended to guarantee the higher metamorphoses of the individual buried in it.

A mathematical model, this actually being valid for every Thracian cult monument, is found to comprise mandatory premises: numerical, aesthetic, ideological, etc., which betray both the religious norm and the canon in art. However, the great diversity of these models rules out strict compliance with all prescriptions. Their creators were far from stereotype solutions. Hence the words of Engels that "every reflection in thought of the world system is limited and remains limited: objectively - by the historical conditions, and subjectively - by the physical and mental frame of its author",[33] are valid still. The ancient builders created a microcosm that reflected their notions about the Cosmos, a highly organized architectural space, which was probably perceived as the mandatory condition or the magic means of gaining access to the demiurge.

Conclusions

As members of the ancient society, philosophers, mathematicians, astronomers, mechanics, etc., took part in its life playing the parts of teachers, speakers in the law courts, inventors of military machines, hoisting devices, etc. However, it would be incorrect to think that from its very inception ancient science served only the rational needs of society. We find that the royal-priestly caste always had the cream of the ancient intellectuals within reach, hence G. M. Idlis is fully justified in claiming that Eudoxus tried to gain an insight into the actual world order, parallel with solving the current calendar problems "related to the need of coordinating the everyday life of people, including the religious rituals considered to be of vital importance".[34]

The application of astronomical data to determine the size of a cult construction did not drain the creative imagination of the ancient builder. The numerical constructs which dominated him since the dawn of human civilization, increasingly sophisticated and linked to geometric constructs,[35] can be detected in the plans of absolutely all representative architectural monuments. Consequently, mathematical and astronomical knowledge, as well as the philosophical notions about the world, played a major role in cult construction (tombs, temples, etc.), as well as in the design and construction of monumental public and civil buildings. The explanations given by Vitruvius of the need of such knowledge, however, are too general. For example, he does not explain why the architect had to "listen carefully to philosophers" and "to have information about astronomy and the celestial laws", why he had

to "understand the system of sundials".[36] Perhaps not the entire information has reached us over the centuries.

The results of the archaeoastronomical research of Thracian tombs allow the reconstruction of a part of the lost or unwritten pages (for obvious reasons) concerning the knowledge and the techniques applied by the ancient people in cult construction. We have tried to demonstrate that knowledge of mathematics and astronomy was used. This knowledge corresponded to the level of ancient science and was subordinated to the pagan religion for creating constructs that materialize the philosophical notions about reincarnation and order in the Cosmos.

The Thracian cults of the dead and the faith in immortality (or divine reincarnation) also have their unwritten theory based on mythological notions, speculative mathematics from the times of Pythagoras and gnomonics, i.e. the teaching about the visible movement of the Sun. Sepulchral construction was born precisely from that theory and it was magic in essence and character. It can be assumed with a very high degree of probability that Thracian sepulchral art was a complex combination of priestly knowledge, a part of which came from Egypt, as well as rational knowledge adopted from neighbouring Hellas.

We intend to extend future research not only on the remaining sepulchral constructions in Thrace, but also on the best documented cult monuments in the Mediterranean region: the Egyptian pyramids, the Parthenon, the Pantheon in Rome, etc. The results of the study allow us also to plan the complete clarification of some texts in Plato's *State* with the help of the reconstructed philosophical and religious concepts in Thracian tombs: *§ 546* (Mengishevo, Ravnogor I, Sveshtary I and Babovo), *§ 587 d, e* (Kazanluk), *§§ 614-621* (Sveshtary II). This means for us that ancient philosophy and religion have common mythological roots, which are detected in the plans and execution of sepulchral construction.

Notes and references

1 Чичикова М. с колектив, 1983, Тракийска царска гробница край Свещари, Разградски окръг, в: *Археологически разкопки през 1982 г.*, Плевен, с. 42-44

2 Иванова Л., 1983, Разкопки на късноантична гробница край с. Бобово, Русенски окръг, в: *Археологически открития и разкопки през 1982 г., Плевен*, с. 95-96

3 We have in mind the tombs measured by us near: Madjarovo, Mezek, Kurt-Kale, Raklitsa, Plovdiv, Strelcha, Hissar I, Kazanluk, Mengishevo, Kaliakra, Sveshtary I, II and III, and Babovo. The two tombs near Ravnogor are also in the same module system. The dimensions of one of the two preserved tombs near the town of Hissar are also determined in Roman feet. For the time being, only the tomb near Pomorie remains with unidentified measuring units.

4 Of the 17 tombs studied and interpreted here, the author has had complete data on the external dimensions of only five of them: Ravnogor I and II, Raklitsa, Plovdiv and Kazanluk. Of particular importance for the study are the outer lengths of five other tombs, i.e. those from Madjarovo, Mezek, Mengishevo, Kaliakra and Babovo.

5 Вачева Кр., Вълев П., 1979, Геодезическата документация на археологически обекти от Античността в България, *Геодезия, картография, земеустройство*, кн. 2, с. 32-36

6 Вълев П., Каменаров А., 1981, Полярният метод при архитектурно - археологическото заснимане в едри мащаби, *Интердисциплинарни изследвания* (*ИИ*), VII - VIII, с. 111-122

7 The author has elaborated and applied some reliable methods for accurate obtaining of the profile line of such complex surfaces as those of the *tholoi*. Naturally, photogrammetric methods are superior in precision, but not in speed and cost-effectiveness.

8 Куликовский П.Г., 1964, *Справочник любителя астрономии*, Москва, (1961), с. 190

Бонев Н., 1964, *Астрономия*, София, с. 273

9 Such is the case with the Late Antiquity tomb at Cape Kaliakra and the one near the village of Babovo.

10 Овчаров Н., Вълев П., 1983, Бележки за крепостта Урвич край Кокаляне и опит за уточняване на името на църквата ú, *ИИ*, X, с. 14: *Фиг. 7*

Вълев П., 1988, Археоастрономическо изследване на слънчев часовник от района на Сердика, *Археология* , кн. 2, с. 47, Обр. 5

11 On the types of errors in the direct measuring of distances, see:

Наръчник по геодезия, 1973, Т. 1, София, с. 270-271

12 Топтанов Д., Вълев П., Дерменжиев В., 1991, Ориентация на скалните гробници от некропол № 1 в археологическия комплекс "Ййла" при с. Камен бряг, Толбухинско, *ИИ*, XVIII, с. 234-237

13 Some Bulgarian authors insist on the explicit recognition that they were the first to examine Thracian sepulchral architecture as the object of geometric and metric investigations: Василева Д., 1987, Гробницата при Свещари - проектиране, оразмеряване и конструкция, *Археология*, кн. 2, с. 6, 8. This fact has not escaped our attention, but nevertheless we believe that the real contribution of a researcher is more important that his or her futile attempts. For example, D.Vasileva claims that Thracian architects "... were completely familiar with and had mastered the mathematical science of their time and had used it for the construction of buildings (tombs)." - Василева Д., 1984, Методът на проектиране на Казанлъшката гробница, *Техническа мисъл*, кн. 1, с. 95. This statement shows that the cited author is totally unfamiliar with the problems of ancient geometry, while at the same time attaches a minor importance to the irrational approach of the ancient people to cult architecture, by categorically rejecting the assumption that predominantly philosophical and religious dogmas and prejudices played a leading role in the design of sacral buildings (Василева Д., 1987, Гробницата при Свещари ..., с. 5-6, 8). What is more, she totally rejects the influence of pagan religion in the formation of the canons of cult architecture.

14 Вълев П., 1985, Свещеният египетски триъгълник, *Проблеми на културата*, кн. 4, с. 100-106

15 See, e.g., Кожухаров Г., 1974, *Сводът в античността и средните векове,*. София, с. 53

16 Вълев П., Op. cit.

Вълев П., 1985, Към историята на геодезическите науки: великата загадка, *Геодезия, картография, земеустройство*, кн. 3, с. 26

17 Fournier A. des Corats, 1957 (réimpression 1985), *La proportion égyptienne et les rapports de divine harmonie*, Paris

Померанцева Н.А., 1985, *Эстетические основы искуства Древнего Египта,* Москва, с. 112

The beginning of the Fibonacci series is as follows: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987, 1597, ... For example, the ratio between 987 and 1597 equals 0.61803338..., i.e. it is possible to obtain M_{φ}, with a precision which exceeds by far the practical needs of the ancient builders.

18 Вълев П., 1984, Наблюдения върху плана на гробницата при село Свещари, *МПК*, кн. 6, с. 21

19 Valev P., 1986, Mathematical models of the Thracian tombs at Kazanluk and Sveshtary, *PACT*, 15, 193-204

20 Perfect numbers in the antiquity (and to this day) are assumed to be those numbers which are equal to the sum of their divisors (without themselves). For example, 6 is divisible by 1, 2 and 3: 1+2+3 = 6; 28 is divisible by 1, 2, 4, 7 and 14: 1+2+4+7+14 = 28.

21 *История на математиката,* 1974, Т. 1., София, с. 79

22 $\sin\xi = \sin\varepsilon / \cos\varphi$.

23 Вълев П.., 1984, Загадъчният камък. - в-к "*Исперихска трибуна*", 30. XII. 1984, бр. 24, с. 2

24 Vasileva D., 1980, L'unité de mesure de longueur dans les constructions thraces, *Thracia,* V, p. 265-300

25 Василева Д., 1978, Монетната система на траките, *Нумизматика*, кн. 1, с. 9.

The theory supported by D.Vasileva about the link between the metric and the monetary system has recently acquired new supporters, who have found on the basis of numismatic material that attempts were made in ancient times to determine the Earth's dimensions: Кучеренко Е.И., 1988, Связь систем мер и весов, использованных в чеканке монет VI-I в. до н. э., с линейными размерами Земли, *ИИ,* XV, 52-53

26 If the gnomon is the symbol of the real world or the symbol of the link between Heaven and Earth, i.e. the role played by the obelisks in Egyptian mythology (Желева-Мартинс Д., 1991, Астрономическа семантика на архитектурната форма, *ИИ,* XVIII, с. 256-264), the shadow may be perceived as the symbol of the world beyond the grave.

27 Вълев П., 1984, Архитектурно - геодезически проучвания на гробницата при Свещари, *Геодезия, фотограметрия, земеустройство,* кн. 5, с. 30. In spite of the critical notes of Д. Василева. Гробницата при Свещари ..., с. 6, we believe that our measurements and calculations are completely correct. Without knowing the site, D.Vasileva had trusted the plans of the tomb, prepared rather artistically by architect T.Teofilov.

28 Кузманов Г., 1971, Раннохристиянска гробница на нос Калиакра, *МПК*, кн. 4, с. 7

In the semi-dark interior of the tomb, it was difficult for us to assess where the plaster had been preserved and where it is missing.

29 According to unpublished calculations.

30 Василева Д., Op. cit., p. 5;

Вълев П., Дерменджиев В., 1988, Бележки-коментар, в: Казо Ч. и Скот Ст. *Ново изследване на големите загадки*, София., с. 266-267: "Here it is necessary to bear in mind a circumstance which is often ignored by specialists working on ancient architectural monuments, namely that these monuments have survived to this day to a greater or lesser extent deformed under the effect of various factors. Let us assume that the ancient builder wished to reflect Nature around him through his cult and other construction, to invest in it his notions about the Cosmos - not as a message to the generations to come, but as a peculiar recognition of the demiurge (his supreme deity - the creator of the Universe). His wishes and their implications are essentially logical in character. Thus, the ancient builder elaborated a design (something like a mathematical model) and attributed to it dimensions in terms of integers and fractions (using suitable fractions for the irrational values obtained for the geometric constructs), i.e. some of the dimensions are approximated (1). Details with erroneously determined dimensions (in spite of the hypothetically ideal mathematical model which the builder elaborated in his mind in the first place) were made less accurately (2), because a moment came when the callipers (i.e. the metal stone-cutting tools for determining the dimensions) became worn out. The superposition or the tracing of the design on the terrain prepared for construction also involves errors (3). Errors occur during the construction as well (4). Centuries and millennia elapse, the buildings undergo deformations as a result of irregular compacting of the soil, earthquakes and other natural phenomena (5). This is followed by the archaeological investigation. The measuring of the explored ancient architectural monuments is also accompanied by contemporary instrumental (angular and longitudinal) errors (6), which are the greater, the more a certain monument has been destroyed, or the less carefully it had been built, or if the measurements have taken place after the intervention of the conservationists. And if we add to the six cases mentioned above some gross mistake on the part of the ancient builders or of the technical personnel measuring the monument today, it would prove that a considerable part of the figures used by professionals researchers and amateurs, qualified by the authors as "adepts of the teaching about numbers", are unreliable. The editors (P.V. in the concrete case) do not rule out the possibility the ancient monuments to have been an adequate and valuable source about the history and natural history, and more specifically of ancient astronomy and geometry, but researchers of architectural and archaeological monuments should always take into consideration the historical period when they were created, the proved level of knowledge during that period, the most probable religious and philosophical notions of the builder (or the royal and priestly caste which he served), and their speculative constructs which should be logically consistent in the minutest detail."

31 The only exception is the inclination of the ecliptic ε, which is practically unchangeable for several centuries: ε decreases by about 1' for 135 years. For the purposes of our study, we have calculated the different values of ε during the antiquity according to Newcomb's universally accepted formula (Newcomb S., 1898, Tables of the Motion of the Earth. Astronomical Papers Prepared for the Use of the *American Ephemeris and Nautical Almanac*, 6)

32 Василева Д., Op. cit., p. 5: "... if he makes the same calculations by using the actually measured lengths in meters, he will obtain results which do not coincide ...".

33 Енгелс Ф., 1985, Анти-Дюринг, в *Карл Маркс, Фридрих Енгелс. Избрани произведения*, Т. 8, София, 46

34 Идлис Г.М., 1985, *Революция в астрономии, физике и космологии*, Москва, с. 32

35 Fitzgerald S., 1926, *The letters of Synesius of Cyrene*, Oxford, p. 258-266 (1581D-1584A): "Astronomy itself is a venerable science, and might become a stepping stone to something more august, a science which I think is a convenient passage to mystic theology, for the happy body of heaven has matter (υλη) underneath it, and its motion has seemed to the leaders in philosophy to be an imitation of mind. It proceeds to its demonstrations in no uncertain way for it uses as its servants geometry and arithmetic, which it would not be improper to call a fixed standard of truth...."

36 Vitr. de arch.: I, 1, 3: "He [the architect - author's note, P.V.] should be a literate man, a skilled artist, he should have studied geometry, he should know history profoundly, he should listen to philosophers carefully, he should be familiar with music and have an idea about medicine, he should know the decisions of lawyers and possess information about astronomy and the celestial laws"; I, 1, 10: "With the help of astronomy, they find east, west, south and north, and they also acquire an idea about the sky, about equinox, the solstice and the motion of the stars ..."

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National Astronomical Observatory Rozhen, 1996
V. Koleva and D. Kolev, eds.

Report on observations and investigations of archaeoastronomically relevant structures in Southern Germany

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Abstract. In the plain, where the river Isar joins the Danube, one of the aerial photographs recently revealed the presence of six circular constructions of ditches. A cartographic documentation was possible using geophysical methods. One of these structures with a very regular elliptical form, was dated in the 5th millennium BC, and interpreted as a calendrical structure.

The investigation of all known Celtic quadrangular earthworks of Bavaria and Baden-Wuerttemberg is now well documented by descriptions and plans. There are regular and irregular quadrangles, trapezoids and parallelograms. We observed characteristic alignments with deviations from north to west and with gates towards the east (71 of 110 Bavarian earthworks). The new interpretation speaks of places of worship and compares the quadrangles with the Greek "temenos".

The investigation of the alignments of Romanesque churches in Southern Germany revealed some structures oriented to the summer solstice sunrise, such as the cathedral of Bamberg, and to the winter solstice sunrise, such as the cathedral of Worms. Is this a Celtic heritage? Some chapels on isolated hills also have a solstitial orientation.

Резюме. В равнината, където реката Изар се влива в Дунав, неотдавна по аерофотографии бяха открити шест кръгли структури от ровове. Картографското им документиране бе извършено с помощта на геофизични методи. Една от тези структури с много правилна елипсовидна форма беше датирана в V хилядолетие пр. н.е. и интерпретирана като календарна структура.

Проучването на всички известни келтски четириъгълни землени съоръжения в Бавария и Баден-Вюртемберг днес е добре документирано с описания и планове. Има правилни и неправилни четириъгълници, трапеци и успоредници. Наблюдавахме характерни ориентации с отклонения на запад от посоката север и с входове на изток (71 от 110 баварски землени съоръжения). Новата интерпретация говори за култови места и сравнява четириъгълниците с гръцките "temenos".

Изследването на ориентациите при романски църкви в Южна Германия разкри някои постройки, ориентирани към слънчевия изгрев в деня на лятното слънцестояние, подобно на катедралата в Бамберг и към слънчевия изгрев в деня на зимното слънцестояние, подобно на катедралата във Вормс. Дали това не е наследство от келтите? Някои параклиси върху изолирани хълмове също имат такива ориентации.

In chronological order from neolithic over Celtic-Iron Age structures to medieval churches the report will give information about some observations of archaeoastronomical interest.

1.

First we look at circular ditch structures. These are ditches forming circles or nearly perfect circles. Inside there is an open space without vestiges of their former use. They lie in the midst of settlements and never on hills or mountains. Since 1977 such structures have been discovered in Bavaria by aerial photography. In 1991 Trnka described 32 circles in Austria, 10 in Southern Germany and 15 in former Czechoslovakia. Isolated and far from this region lies the circular ditch of Bochum-Herpen, made known to us by Wolfhard Schlosser at the Strasbourg-Meeting in 1992.

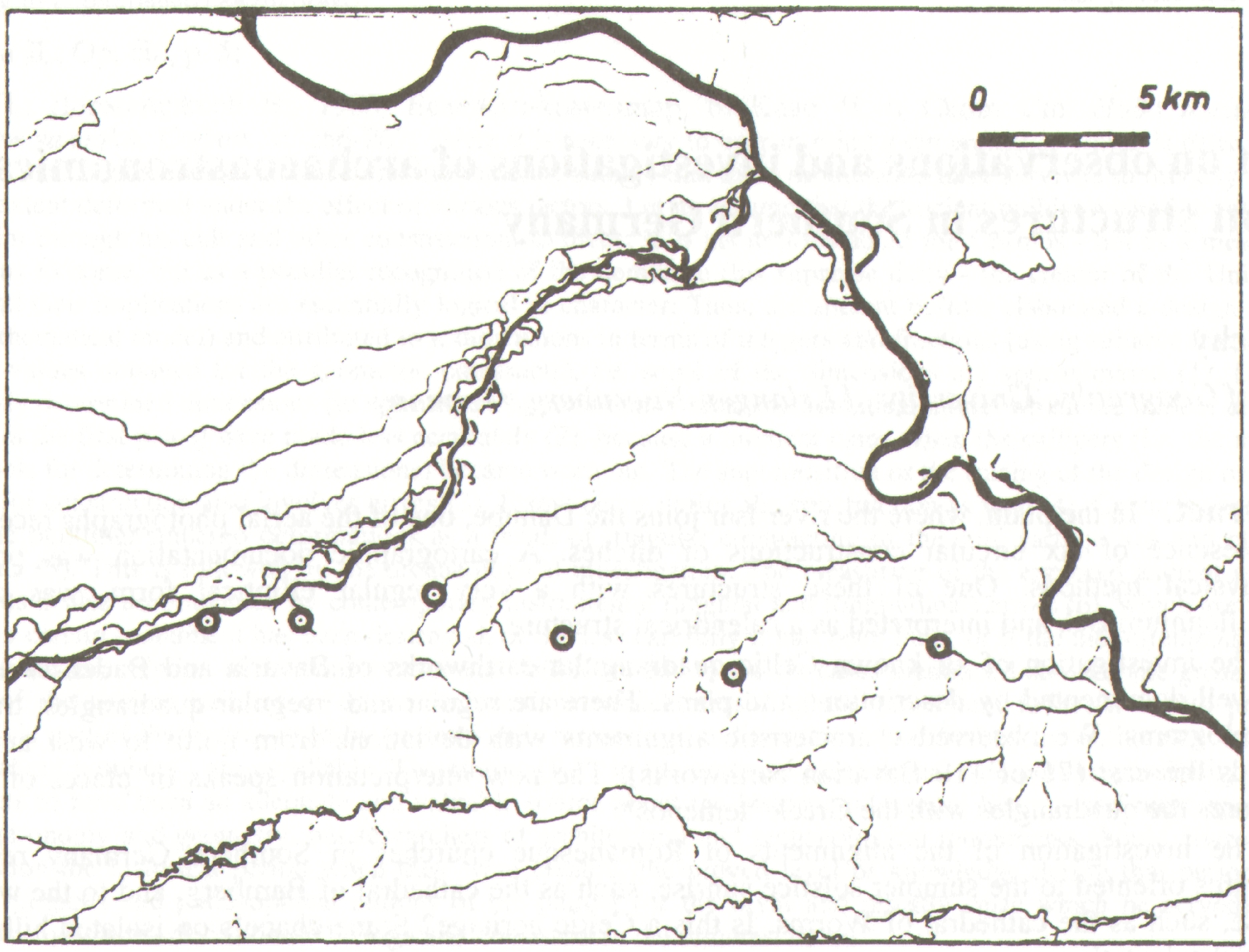

Figure 1. Situation of the six middle Neolithic circular ditch structures of the group in Unternberg-Kothingeichendorf, where the Isar enters the Danube from East to West: Kuenzing-Unternberg, Osterhofen-Schmiedorf, Wallerfing-Ramsdorf, Oberpoering-Gneiding, Meisternthal, Landau-Kotingeichendorf. From Becker 1990 Fig. 4.

In the plain, where the river Isar joins the Danube, there are six circular ditches aligned from west to east (Fig. 1). The settlement areas cover up to 10 hectares. They lie on loamy soils over loess near streams. They have diameters from 40 to 100 meters and ditches up to 5 meters deep. Not until 1982-1989 were the circles on the ground investigated using geophysical-magnetic methods. According to radiocarbon dating they were constructed at the beginning of the 5th millennium, thus they are a millennium older than Stonehenge I. The circle of Bochum, which is equally old, is a perfect circle, whereas the Bavarian structures have irregular forms.

What is outstanding is the exact ellipse of Meisternthal, which was magnetically prospected by H. Becker in 1982 and 1989 (Fig. 2). The aerialphoto-plan shows the perfectly aligned north/south axis, 45 m long, and the east/west axis, 36.5 m long. Two gates are open to the east and to the west with the azimuths 91° and 271° and the horizontal height of 1°; but not only the equinoctial points of sunrise and sunset could be observed, but also the summer- and winter-solstice sunrises and sunsets. The focal points of the ellipse have been reconstructed, but the excavators found no traces of postholes at these points. Seen from the focal points, there are sightlines through the middle of the gates to the four solstitial points. Here at the geographical latitude 48°40'50" the azimuths of the solstitial sunrise points are 53° and 127°.

Whereas in most cases at other structures only a few dates of sunrises or sunsets are determinable, here we evidently have a complete calendar of the year. Between the focal points, after Becker, the periods of a 16 month solar calendar could have been marked. Insignificant discolored spots in the soil are indicators of this. (The focal points are 26.6 m apart, i.e. 32 units of 0.831 m - "neolithic yards", of A. Thoms's MY of 0.829 m.)

The easternmost circular ditch was found near the Danube at Kuenzing-Unternberg (48°40'; Fig. 3). There are two circles. Half of the structure was disturbed by the consolidation of farmland, but now the whole of it has been revealed by magnetic prospecting. The outer diameter is 110 m. The gates to the west and east have a deviation of 37°, i.e. they are directed to the winter solstitial sunrise point (127°) and the summer solstitial sunset point (307°). Another two-ditch structure, that of Kamegg am Kamp north of Krems/Danube, is described by Trnka (1991) from Lower Austria. The four gates have a deviation of 11°-12° from the four cardinal points, see the reconstruction (Fig. 4). The absolute age is about 3800 BC.

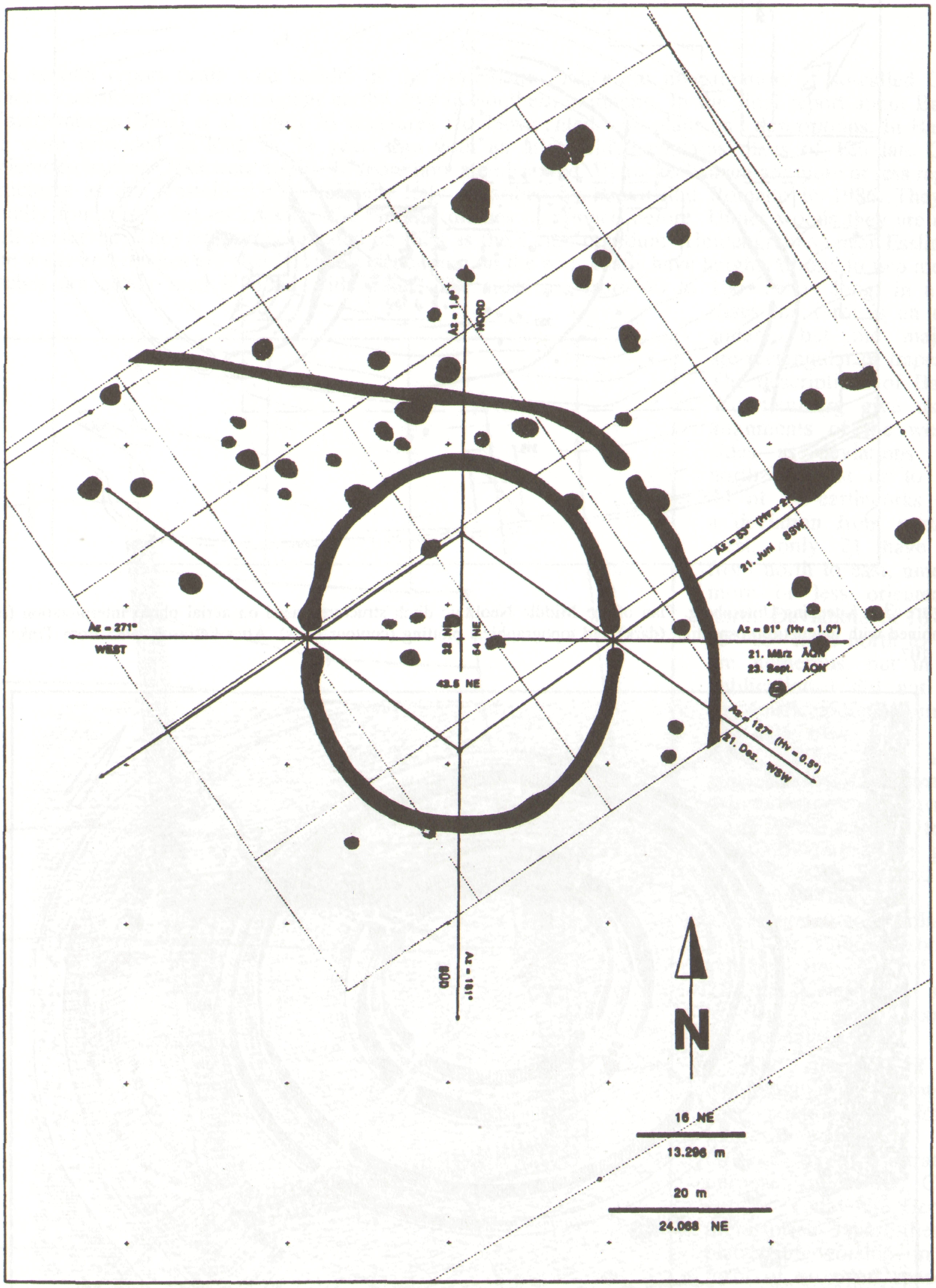

Figure 2. Circular ditch structure near Meisternthal. Interpretation as calendar architecture. Plan is based on magnetogramm and "Höhenflurkarte". Ellipse reconstructed in neolithic units (0.831 m). Sightlines, azimuth and horizontal height to the sunrise points at summer solstice, equinoxes and winter solstice in the 5th millennium BC, to the west the accompanying sunset directions. From Becker 1990 Fig. 7.

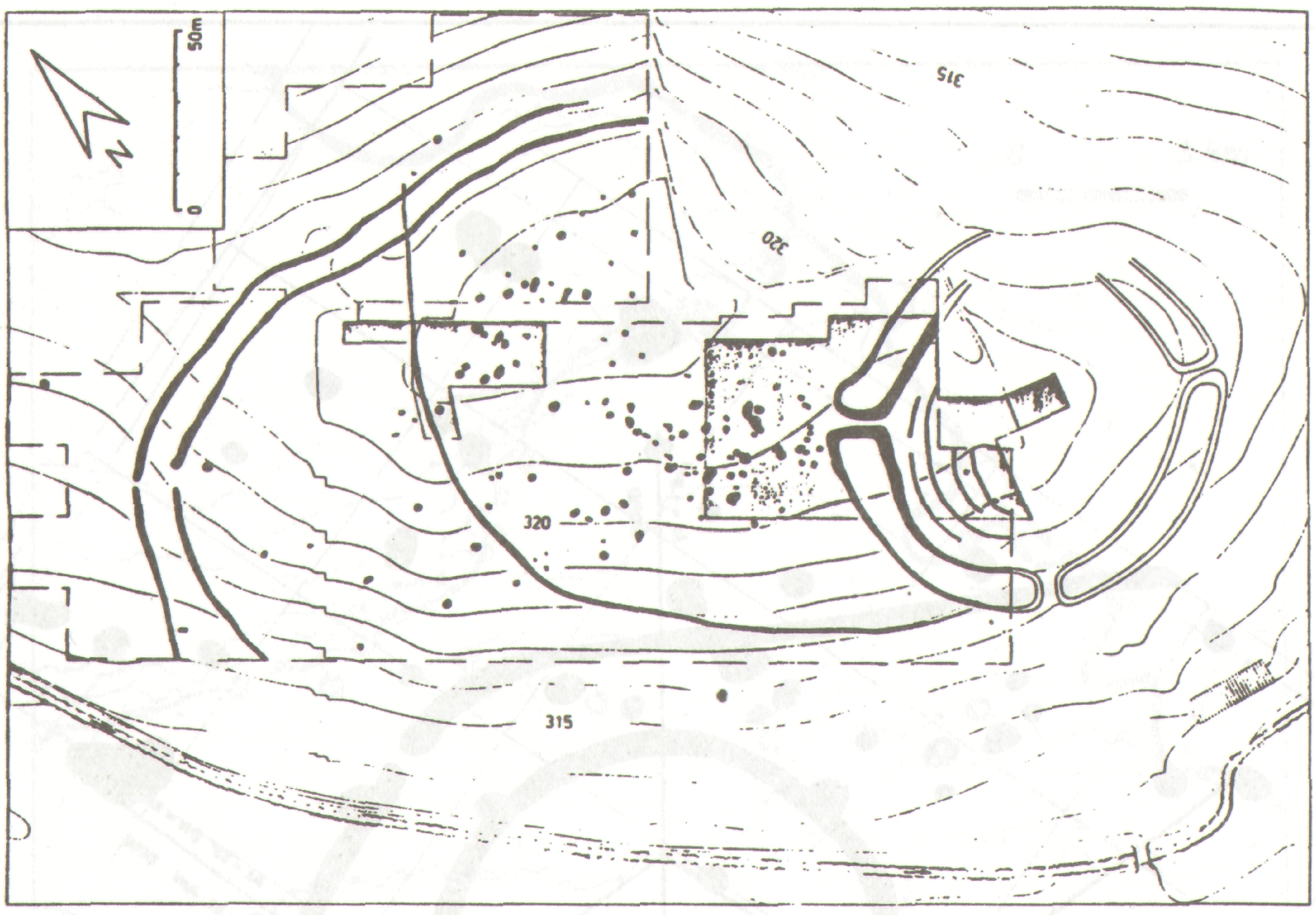

Figure 3. Kuenzing-Unternberg. Plan of the Middle Neolithic ditch structure based on aerial photo interpretation (open) combined with magnetic prospecting (dark) and topographical plotting (contour lines). After Petrasch 1985 from Trnka 1991 Fig. 107.

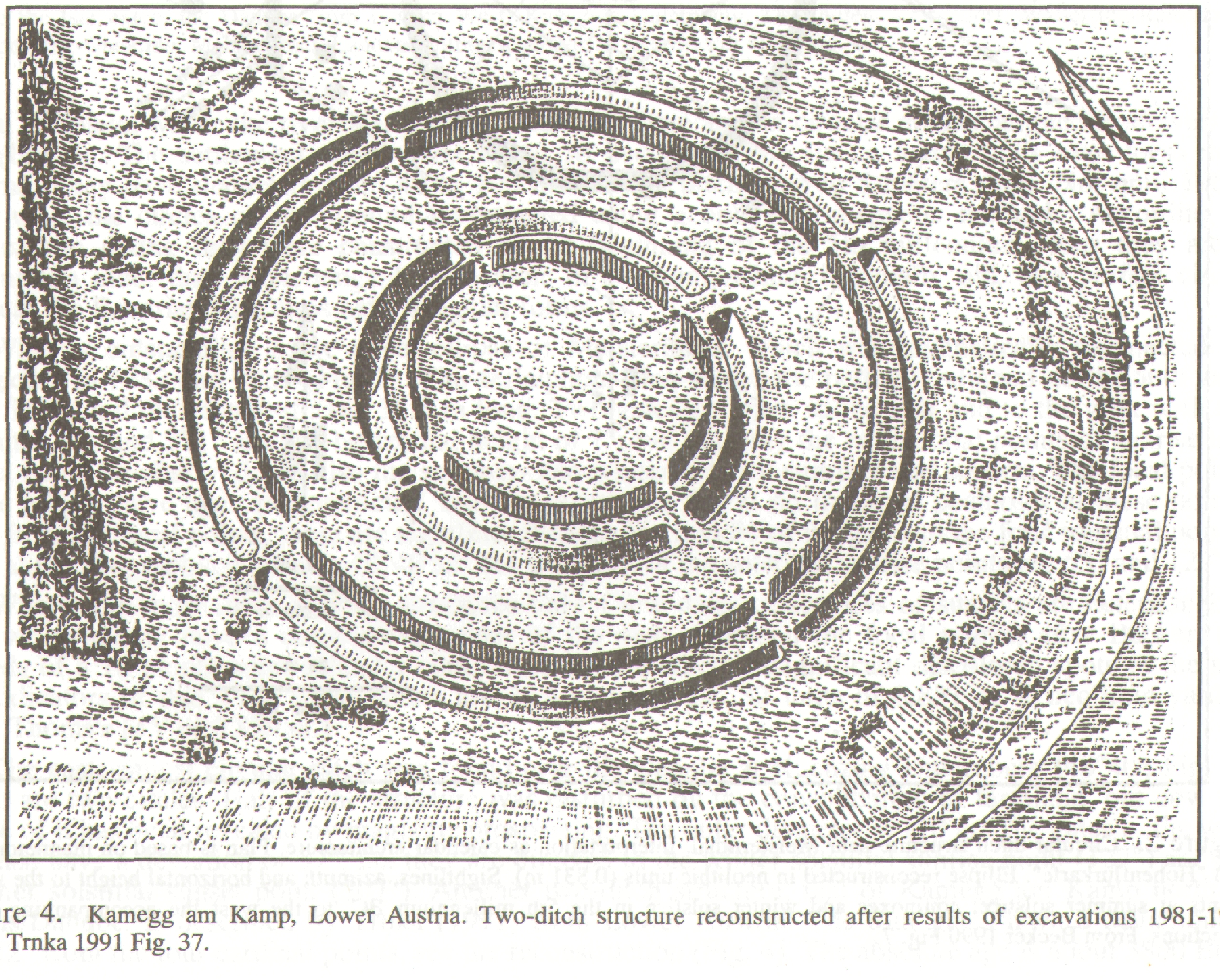

Figure 4. Kamegg am Kamp, Lower Austria. Two-ditch structure reconstructed after results of excavations 1981-1988. From Trnka 1991 Fig. 37.

2.

The second report deals with results of the systematic prehistoric investigation of so-called Celtic "Viereckschanzen" or quadrangular earthworks in Southern Germany. In the final report about Baden-Wuerttemberg (Bittel et al. 1990) 76 structures are documented with plans and descriptions. In Bavaria we were provided as long as 34 years ago with an atlas which contains plans of 120 late Celtic "Viereckschanzen" (Schwarz 1959). 40 more now are observed. Viereckschanzen are more or less regular structures as the "castellieri" of Northern Italy described by Aveni and Romano in 1986. They are usually found in a flat area, as are the circular ditches mentioned before. Under woods they are often well-preserved. They are rarely situated on hills as the Celtic oppidum "Heidengraben" near Esslingen. The walls and ditches are clearly visible depending on the soil. Walls have heights of one to two meters, ditches are easily seen if filled with water. The sides are from 40 to 100 meters long: in a few cases the form is an exact square, but the majority are rectangular or trapezoid. The descriptions of Baden-Wuerttemberg give us the alignments of the western sides as deviations from north to west or to east. 44 of 74 earthworks have a deviation from north to west, only 21 have one from north to east, nine are more or less oriented to north. Deviations of 10° and 15°-18° from north to west are numerous, but in this publication I did not find any solstice point alignment. The Bavarian atlas does not inform us about alignments. We can measure the directions of gates or sides in the plans. I tested eight structures with gates to NW, SW, SE and NE and found only one with an alignment to a solstitial point, to summer solstice sunrise. But six of the 71 gates towards east seem to be oriented exactly equinoctially.

The function of the quadrangular earthworks was controversial for a long time. Surely they do not have a strategic purpose, unlike the Celtic oppida. Today the German prehistorians regard them as places of worship in the form of an open space in the settlement area of a village. They compare the quadrangles with the Greek "temenos", with its holy grove or a temple (Schwarz 1975).

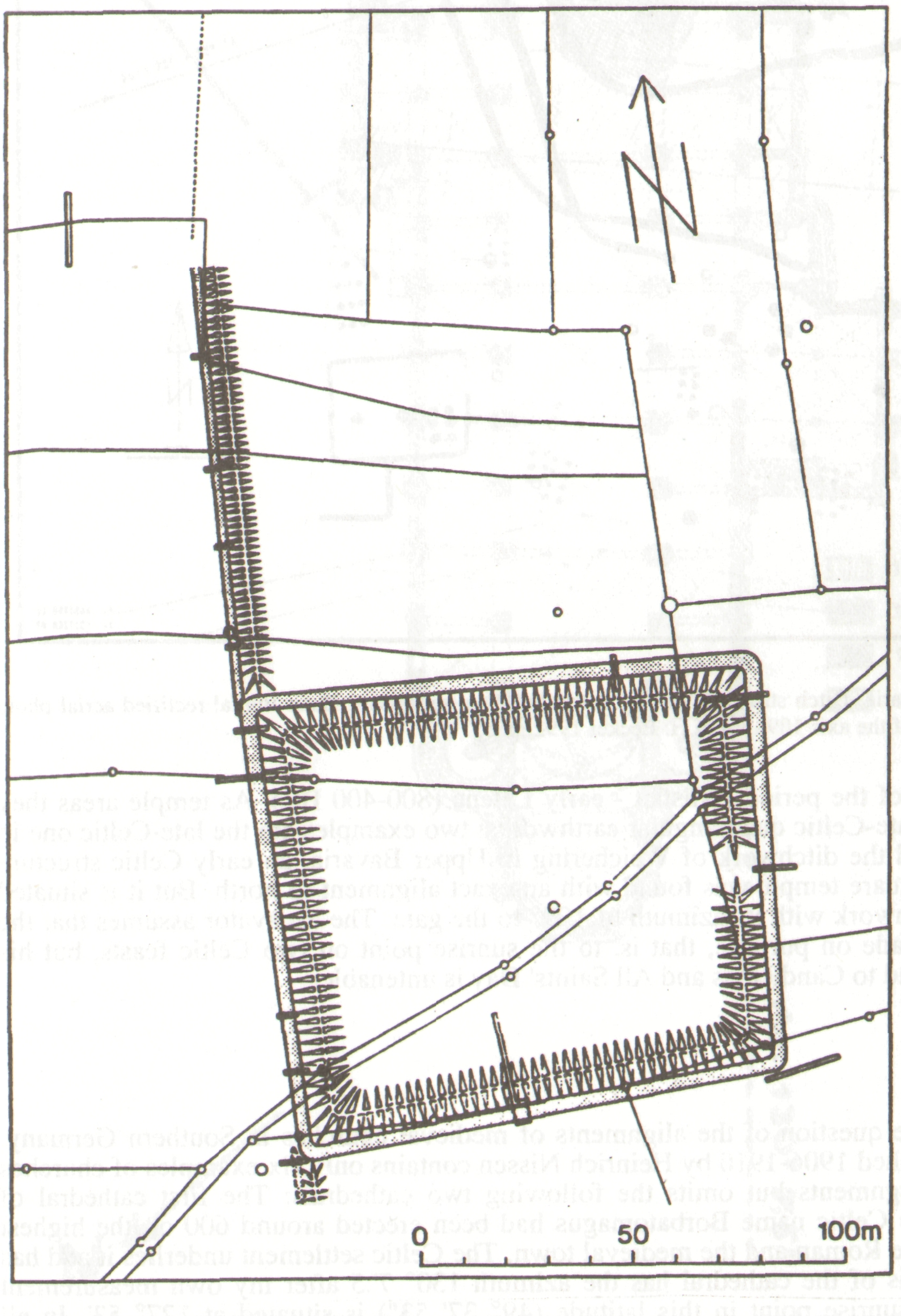

Figure 5. Late-Celtic "Viereckschanze" or quadrangular earthwork of Weißenburg/ Frankonia. After L. Wamser from Spindler 1987 Fig. 97.

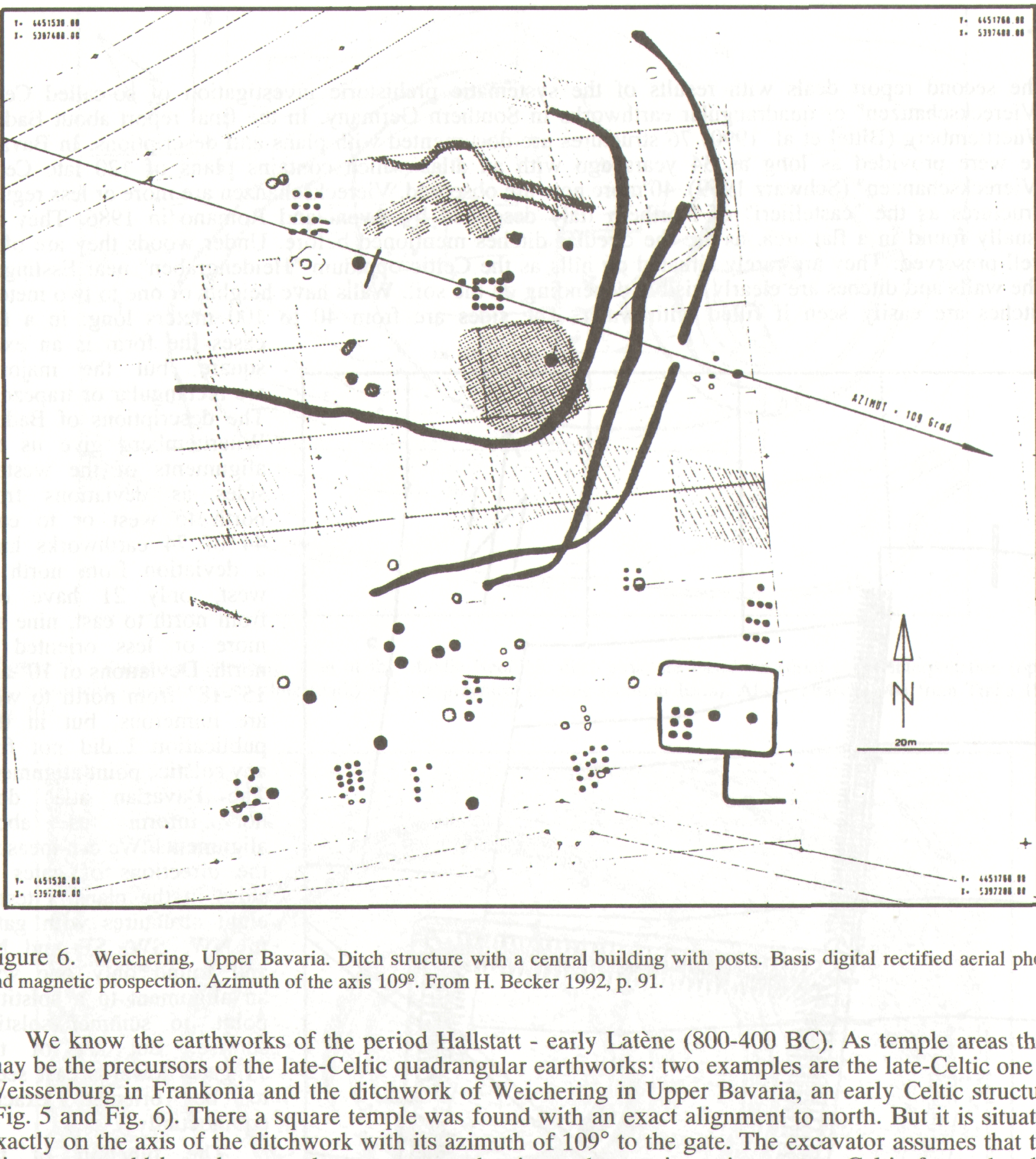

Figure 6. Weichering, Upper Bavaria. Ditch structure with a central building with posts. Basis digital rectified aerial photo and magnetic prospection. Azimuth of the axis 109º. From H. Becker 1992, p. 91.

We know the earthworks of the period Hallstatt - early Latène (800-400 BC). As temple areas they may be the precursors of the late-Celtic quadrangular earthworks: two examples are the late-Celtic one in Weissenburg in Frankonia and the ditchwork of Weichering in Upper Bavaria, an early Celtic structure (Fig. 5 and Fig. 6). There a square temple was found with an exact alignment to north. But it is situated exactly on the axis of the ditchwork with its azimuth of 109° to the gate. The excavator assumes that the alignment could have been made on purpose, that is, to the sunrise point on two Celtic feasts, but his assumption that they correspond to Candlemas and All Saints' Day is untenable.

3.

The third report deals with the question of the alignments of medieval churches in Southern Germany. The work "Orientation", published 1906-1910 by Heinrich Nissen contains only six examples of churches in Germany with solstitial alignments but omits the following two cathedrals: The first cathedral of Worms; the old town with the Celtic name Borbatomagus had been erected around 600 on the highest point and on the outskirts of the Roman and the medieval town. The Celtic settlement underlies it and has not been investigated. The axis of the cathedral has the azimuth 130° 7'.5 after my own measurement (Fig. 7). The winter solstice sunrise point in this latitude (49° 37' 53") is situated at 127° 53'. In all probability, the Roman town adopted not only the Celtic name but also the old solstitial orientation, and the cathedral followed this tradition.

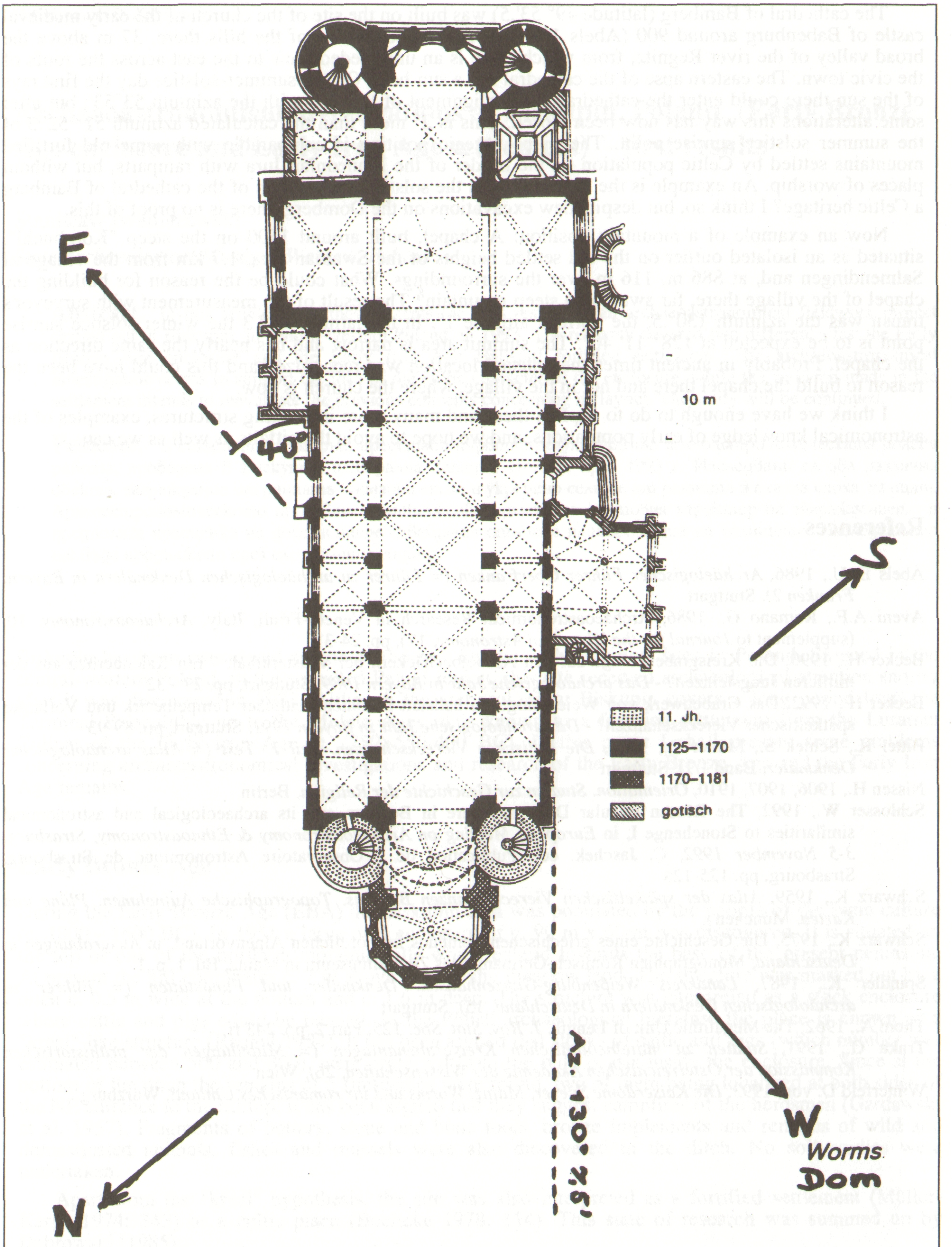

Figure 7. Worms. Plan of the cathedral and the alignment. Plan from von Winterfeld 1993.

The cathedral of Bamberg (latitude 49° 53'.5) was built on the site of the church of the early medieval castle of Babenburg around 900 (Abels 1986). It is situated on one of the hills there, 37 m above the broad valley of the river Regnitz, from which there is an unimpeded view to the east across the roofs of the civic town. The eastern apse of the cathedral has a sun-hole. On the summer-solstice day the first rays of the sun there could enter the cathedral in the alignment of the axis with the azimuth 53°53'; but after some alterations this way has now been closed. This is 2° more than the calculated azimuth 51° 52'.3 of the summer solstice sunrise point. The high strategic position is comparable with some old fortified mountains settled by Celtic population on the border of the Franconian Jura with ramparts, but without places of worship. An example is the Staffelberg. Is the solstitial orientation of the cathedral of Bamberg a Celtic heritage? I think so, but despite new excavations on the Domberg, there is no proof of this.

Now an example of a mountain position: A chapel, built around 1500 on the steep "Kornbuehl", situated as an isolated outlier on the old settled heights of the Swabian Jura, 1.7 km from the village of Salmendingen and, at 886 m, 116 m over the surroundings. What could be the reason for building the chapel of the village there, far away on a steep mountain? The result of the measurement with surveyor's transit was the azimuth 130°.5, the horizon altitude 1°. In the latitude 48°.3 the winter solstice sunrise point is to be expected at 128° 11' 40". The summit area is narrow and has nearly the same direction as the chapel. Probably in ancient times the unusual location was recognized and this could have been the reason to build the chapel there and not in the village, where the church is now.

I think we have enough to do to explain these and many more interesting structures, examples of the astronomical knowledge of early populations, and we hope to avoid the pitfalls as well as we can.

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Astronomical Traditions in Past Cultures
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Positional systems for solar and lunar observations in the archaic cultures in Bulgaria

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Abstract. The indisputable necessity of astronomical observations for ancient societies caused the creating of observational methods and equipment. All of them, together with the possibilities of the naked eye, laid the beginnings of specific positional systems for solar and lunar observations. For societies who lived in the area that is Bulgaria today (φ = 40°- 45°), an area with a temperate climate, the sun's and moon's motions are specific and it was necessary to know sunrise and sunset points at the moments of equinox and solstice for their observations.

Several types of positional systems connected with characteristic forms of the natural relief have been studied. Line of sight equipment marking characteristic solar disk positions on the horizon and possible methods of their use are described.

It was found that the moments of equinoxes were defined with an accuracy of ±1 day. The moments of solar and lunar crossing of the prime meridian and their characteristic culminations at the observational place were fixed with an error of ±1 arc degree and ±2 days. The main sunrise directions on the horizon line during the equinoxes and solstices are defined with an accuracy of ±20 arc minutes.

Резюме. *Безспорната необходимост от астрономически наблюдения при древните безписмени общества поражда създаването на наблюдателни методи и съоръжения. Всички те, заедно с възможностите на "простото око", поставят началото на специфични позиционни системи за наблюдение на Слънцето и Луната. За обществата, обитаващи умерения климатичен пояс с географска ширина φ = 40°- 45° на територията на днешна България, движенията на Слънцето и Луната са специфични и за наблюдението им се изисква познаването на точките, свързани с техните изгреви и залези в моментите на равноденствие и слънцестояние.*

Разгледани са няколко позиционни системи, свързани с характерни форми на естествения релеф. Описани са визирните съоръжения, маркиращи характерни положения на слънчевия диск върху линията на хоризонта и възможната методика за използването им.

Установено е, че моментите на равноденствията са определяни с точност до ±1 ден, а преминаването на Слънцето и Луната през главния меридиан и характерните им кулминации в мястото на наблюдението е фиксирано с грешка ±1 дъгов градус и ±2 дни. Основните направления на изгрева на слънчевия диск върху линията на хоризонта по време на равноденствията и слънцестоянията са определяни с точност ±20 дъгови минути.

A great amount of literature dedicated to ancient archaeological monuments proves that they were adjusted for determining accurate rise, set and culmination positions of heavenly bodies on the line of local horizon and observational meridian (Ruggles 1982; Wood 1981; Radoslavova 1993). For these reasons the equipment was arranged so as the system of "sights" and "foresights" attracted the observer's sight to a characteristic relief mark on the local horizon. The sun, moon, and bright planets and stars were the observed heavenly bodies. We could name devices, created in such a primitive way, "positional systems for visual observations" of bright heavenly bodies in the sense of contemporary astrometrical concepts.

On the other hand, the use of the architectural-relief elements of the rocky sanctuaries in ancient Thracia in the process of astronomical observations concerned a lot of researchers. Several rocky sanctuaries have been studied in detail and the results have been published in scientific literature (Stoev et al. 1990; Stoev and Stoytchev 1991; Dermendjiev et al. 1984). Nowadays it is already clear that the culture of ancient Thracians was verbal and described by observant foreigners visiting it at that time. Their culture could be found in objects of life, art, and technology from this epoch. The subject-matter and style were inspired by Thracian religious thinking (Fol 1975, 1986). Rocky sanctuaries in Thracia and the Rhodopes were devoted to different divinities. Thracians did not have an organized priest class and written tradition. That's why the creation of a united cosmogony theory represented in Thracian beliefs was very difficult. At the end of the Bronze Age solar and light symbols predominate. The honouring of the Solar God by the Thracians is attested in a number of archaeological objects on today's Bulgarian land (Gocheva 1990; Raduncheva 1990).

According to rocky sanctuary classification (Najdenova 1986) we could determine some typical characteristics of their locality and the elements of sanctuaries of typical astronomical function.

For example:

1. They are often placed on high mountain peaks and rocky heights. The astroclimate of such places is distinguished for a great number of clear days and nights during different seasons.
2. The architectural elements of the sanctuary are chosen so as they could be lit up by the first solar rays. On the east side of some sanctuaries small rough bays or stone circles are even hewn out. It is evident that the first solar rays' contact with these elements had a definite ritual meaning.
3. Iconographic solar images incarnated in so called "stone suns" are found at almost every discovered sanctuary. Images are slightly protruding over the main rock and are usually oriented eastward but in some cases southward.
4. There is an observational ground placed on the top of the rock from where the local horizon or part of it could be seen. The observational ground is characterised by multiple natural or artificial formations used during observations.
5. Stairs hewn into the rock lead to the highest point of the sanctuary. In some places there are natural caves or deliberately cut out bays. Sometimes human or animal rock reliefs are found.
6. Artificial landmarks such as mounds and embankments are usually found near the sanctuary. Sometimes they are placed on the local relief horizon.
7. Very often the sanctuaries are combined with natural caves in the base rock. It could be supposed that the observer used these places for accommodation before nightfall.

Thus, by definition the positional systems are material objects and artefacts which together with other data about the local horizon character, heavenly bodies' visibility in the considered epoch, social necessity, etc., gave the ancient society the possibility to observe the celestial sphere with different time and space resolution. Taking into account the basic tasks of archaeoastronomy and particularly its concrete objects we could:

a) define the region from the celestial sphere containing observational objects, the geographical environment as a part of the "primitive observational equipment - observer" system and the period of the object's functioning. All these things form the spatial - time frames of the investigation and manner of their astronomical usage.

b) define the society type whose material monuments are studied by archaeoastronomy. Ultimately, the archaeoastronomical scientific methodology takes into consideration the observational manners, instruments, and heavenly objects according to place, time (epochs), society structures, and necessity.

Objects and monuments united in the term "positional systems" are various. All of them with no exclusions are material monuments and are included in the object of archaeology. In addition, the megalithic monuments, the exactly oriented architectural patterns, rocky paintings and graffiti with calendar content form the final result from the observations. Their functions in the initial context could not be openly presented. This leads to difficulties in archaeoastronomical interpretation. We should also add geological knowledge about the processes of earth surface changes as a result of natural evolutionary processes (site relief is an important factor in archaeoastronomical interpretations). It is very difficult to assess the accuracy of ancient observations by the measures of 20th century astronomy. It should also be taken into account that the metric accuracy of ancient positional systems is a derivative of measure procedures about which written or other sources are absent. In addition, astronomical aims are involved in numbers of other social, aesthetic, etc., purposes, characteristic for the respective epoch (Burl 1980).

Two kinds of research operations in concrete investigation work on positional systems could be seen:

a) connected with the immediate studying of archaeological material objects and their astronomical use (so called precise mapping, target pole positions, local relief, sky and heavenly bodies in the respective epoch);

b) connected with theoretical considerations, as a result of which the archaeoastronomer passes from collected field data to well-grounded suppositions about their astronomical use in different social-psychological directions of the ancient society. Chronological and geographical attributes, sky and observational objects reconstruction, conclusions about the social necessity and organization of the astronomical data, religious practices, building technology and use in practice - everything should be precise and detailed.

Let us concentrate our attention on two important examples of Bulgarian archaeoastronomical objects. One of them is near the Mostovo village, Plovdiv district, placed in the central Rhodopes, Belintash place. This sanctuary is a big rocky plateau with a surface of 5000 sq. m prolonged in the direction north - south, divided into three parts (Stoev and Muglova 1991). The rocky plateau is separated by the local horizon with deep river valleys and well preserved stairs which lead to the remains of a building basement cut in to the rock.

About 260 circular hollows of artificial origin are hewn out of the central part of the plateau (see Fig. 1). A rocky mound with a lot of ash on the top is found on the north-east horizon. Originating from the Thracian cult towards the sun, the idea of observation of sunrises at the days of summer solstice was developed. Studying the disposition of the circular hollows one can see that their number, related to single angular sectors in the area between 0° - 90°, shows well expressed concentration around the direction east - northeast (see Fig. 2). Developing the hypothesis it could be assumed that in these hollows poles defining the line of sight towards the point from the horizon, in which the sun rises on the day of the summer solstice, were mounted (see Fig. 3). The azimuth of the sunrise on the day of the summer solstice has been calculated at the detailed studying of the sunrise for the epoch of the 1st millennia BC (the time of the active functioning of the sanctuary) (see Fig. 4). The sunrise on the day of summer solstice was not related with a characteristic relief peculiarity from the local horizon. That is why an artificial mound - marker was necessary to be made on the local horizon.

If a radial section of the central part of the plateau is made, it could be seen that the hollow number at concentric arcs forms two maximums (see Fig. 5). They are situated towards the sunrise direction on the day of summer solstice and towards the sunrise direction during the spring and autumn equinox (see Fig. 6). The number of the circle hollows is greater than necessary for the aims of positional sighting. It could be explained by the long use of this astronomical equipment. The assertion that the ancient observer should correct the sighted lines for better accuracy is convincing. It is possible that some of the hollows connected with a taking sight at sunrises at corresponding spots on the horizon on characteristic days of the year have had a cult - religious purpose.

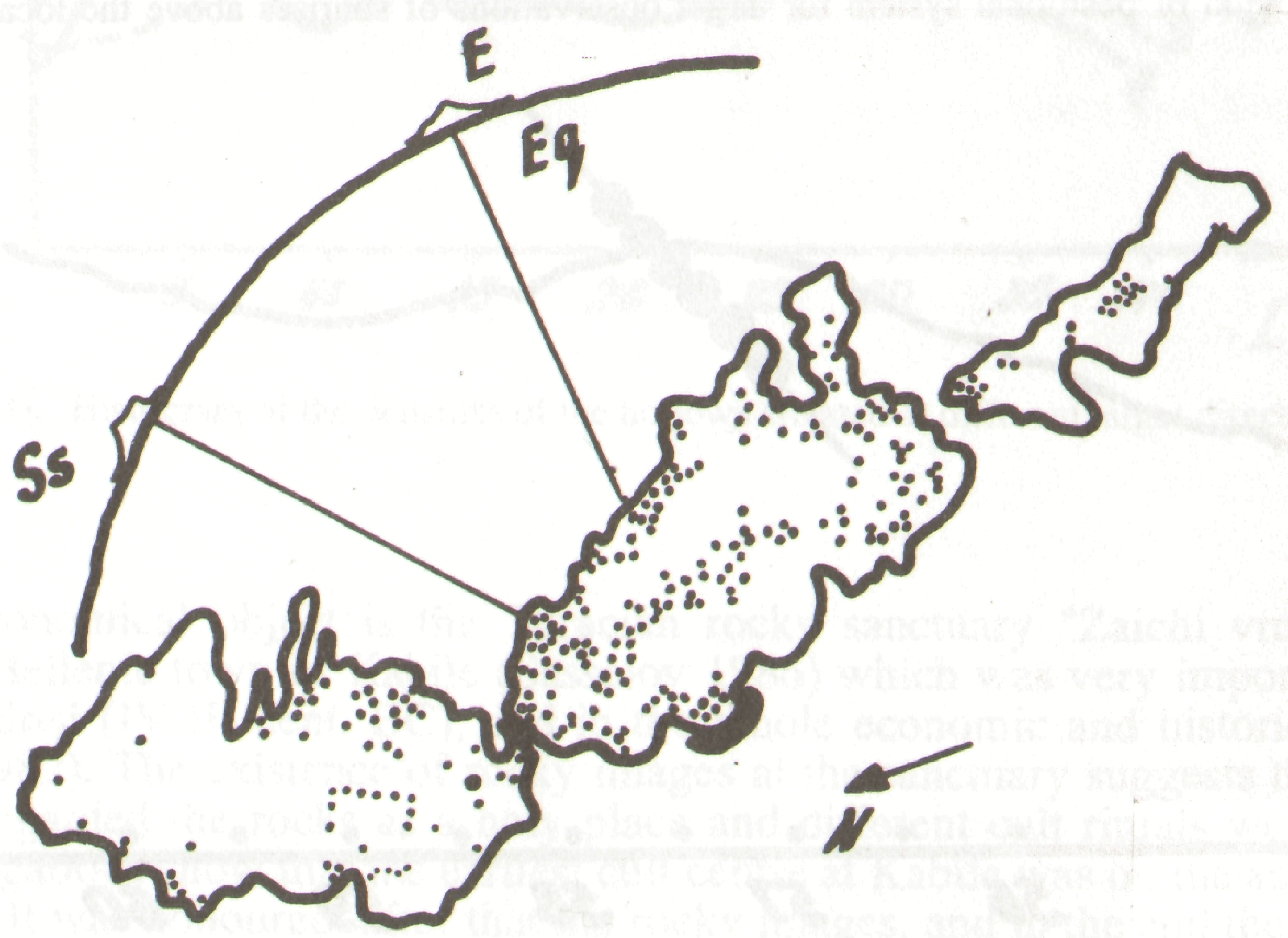

Figure 1. Horizontal plan of the Belintash sanctuary and its orientation in relation to the local horizon.

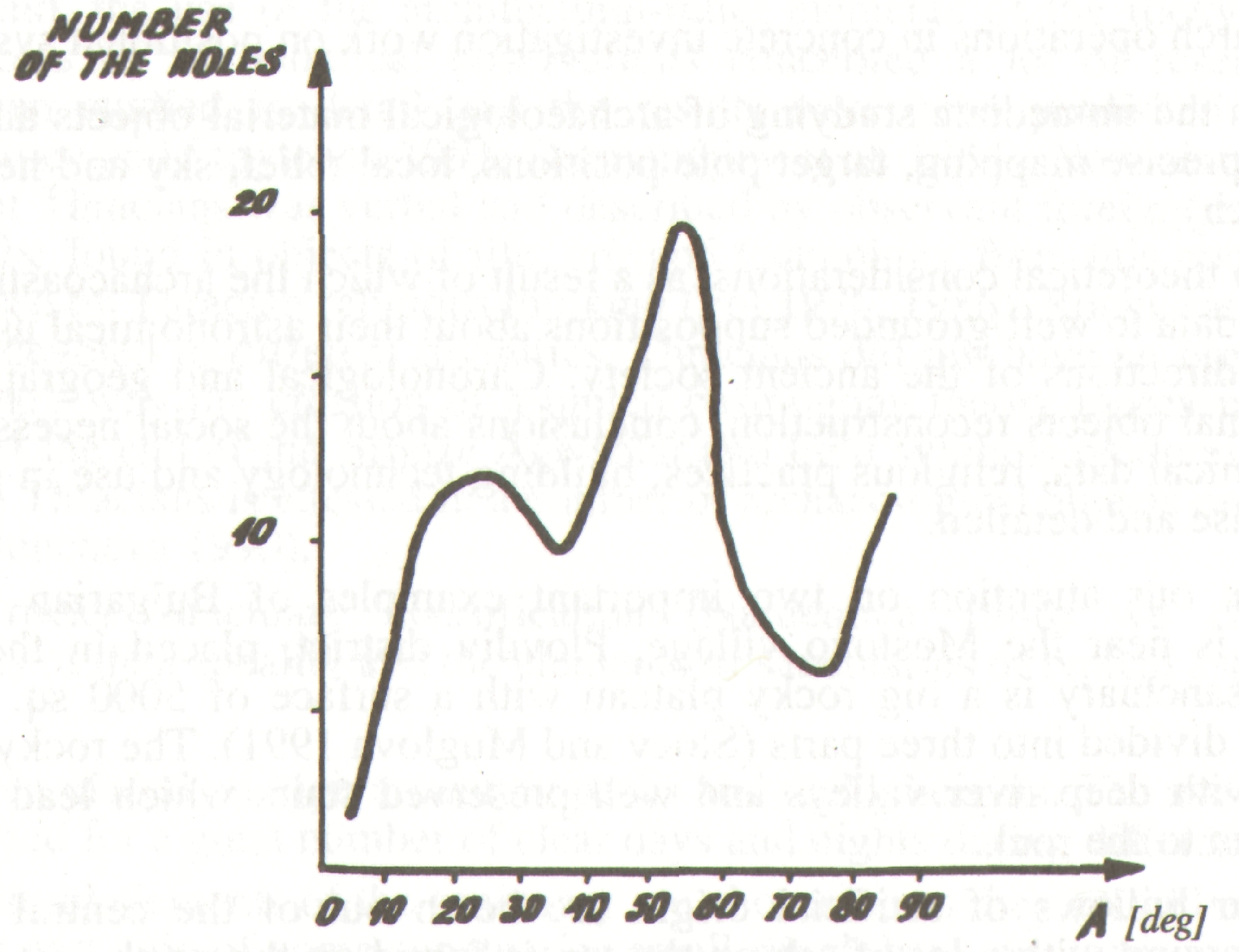

Figure 2. Histogram of the circular hollows' angular distribution on the rock sanctuary in direction east-northeast.

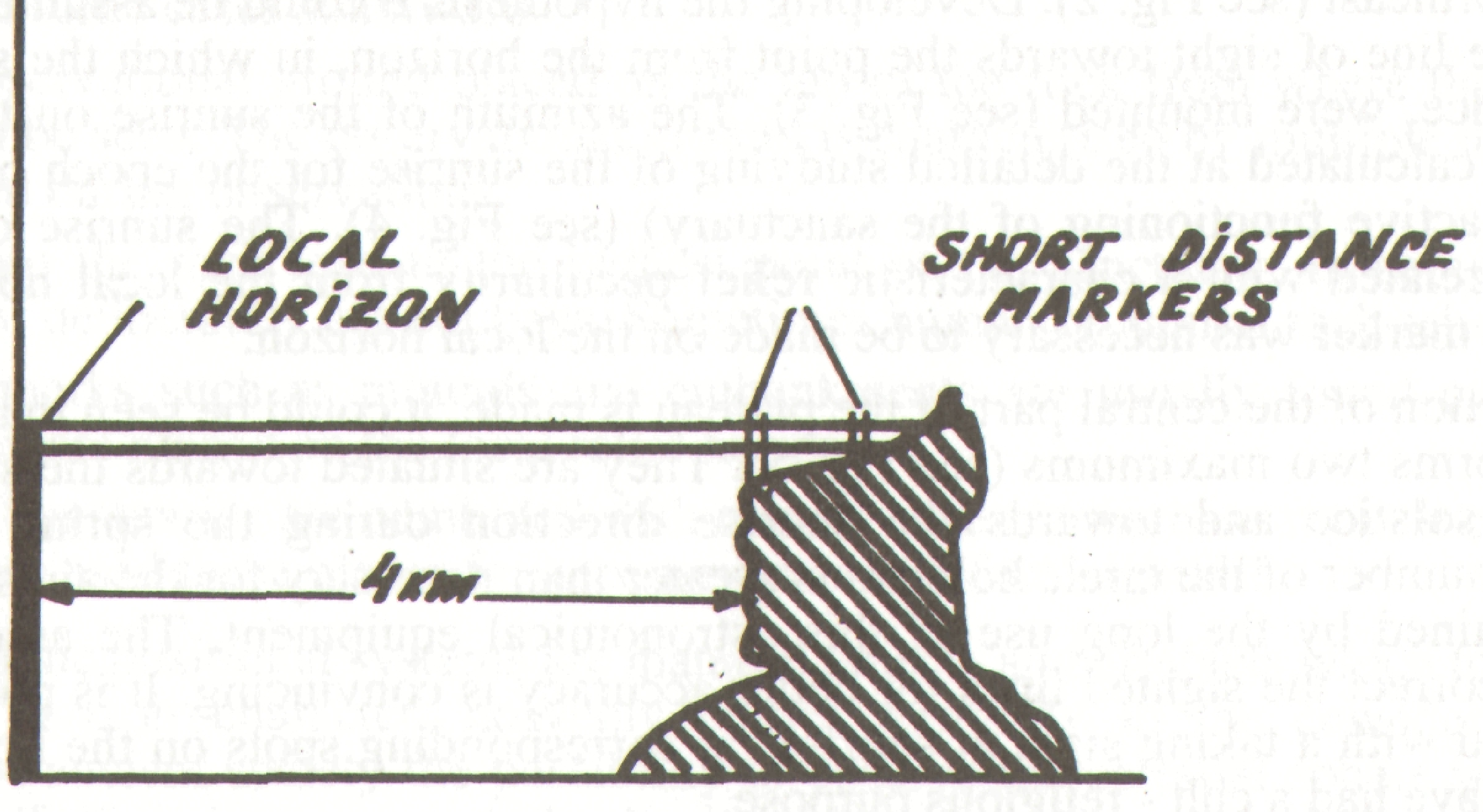

Figure 3. Interpretation of positional system for target observations of sunrises above the local horizon on the day of the summer solstice.

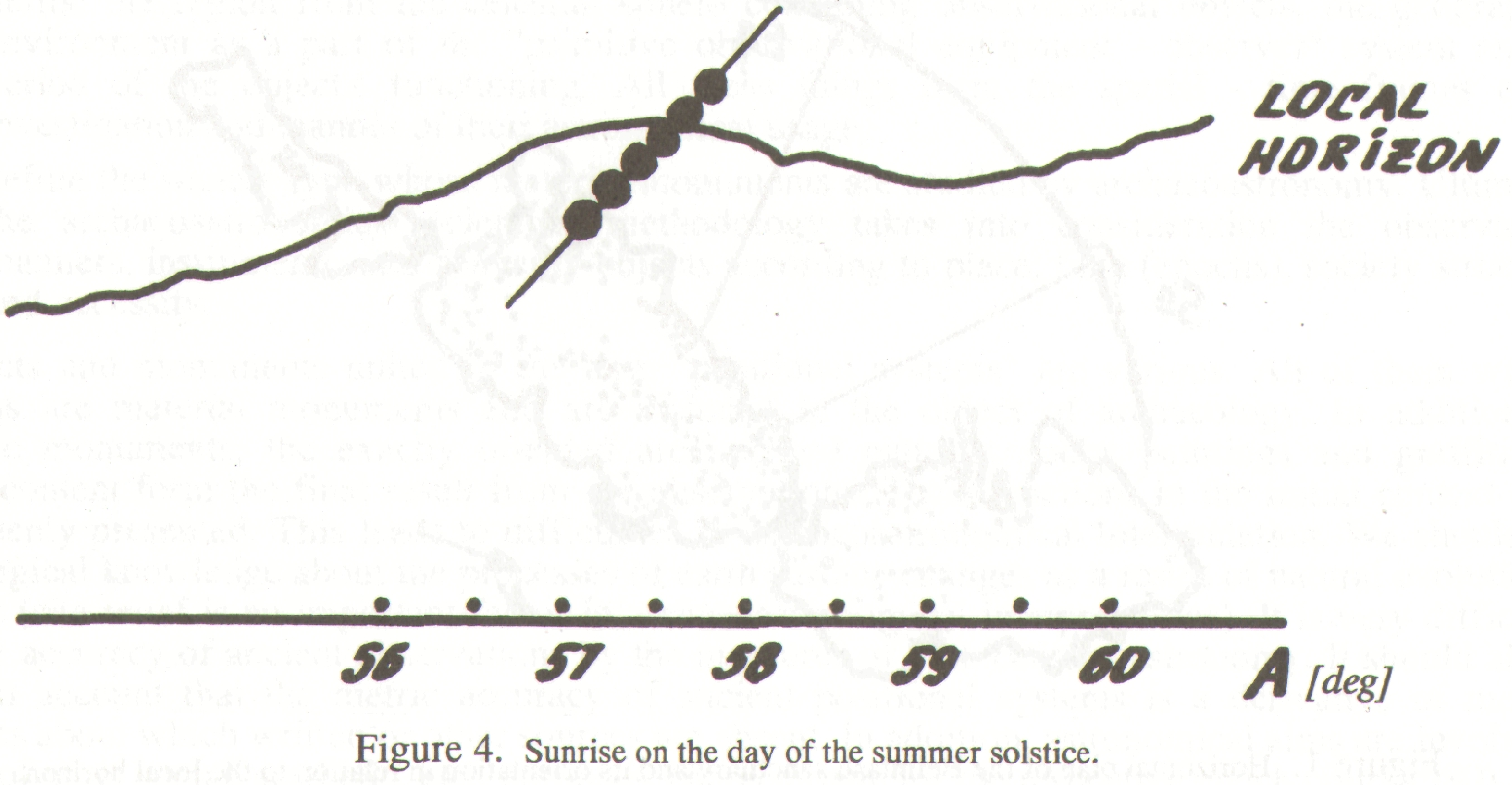

Figure 4. Sunrise on the day of the summer solstice.

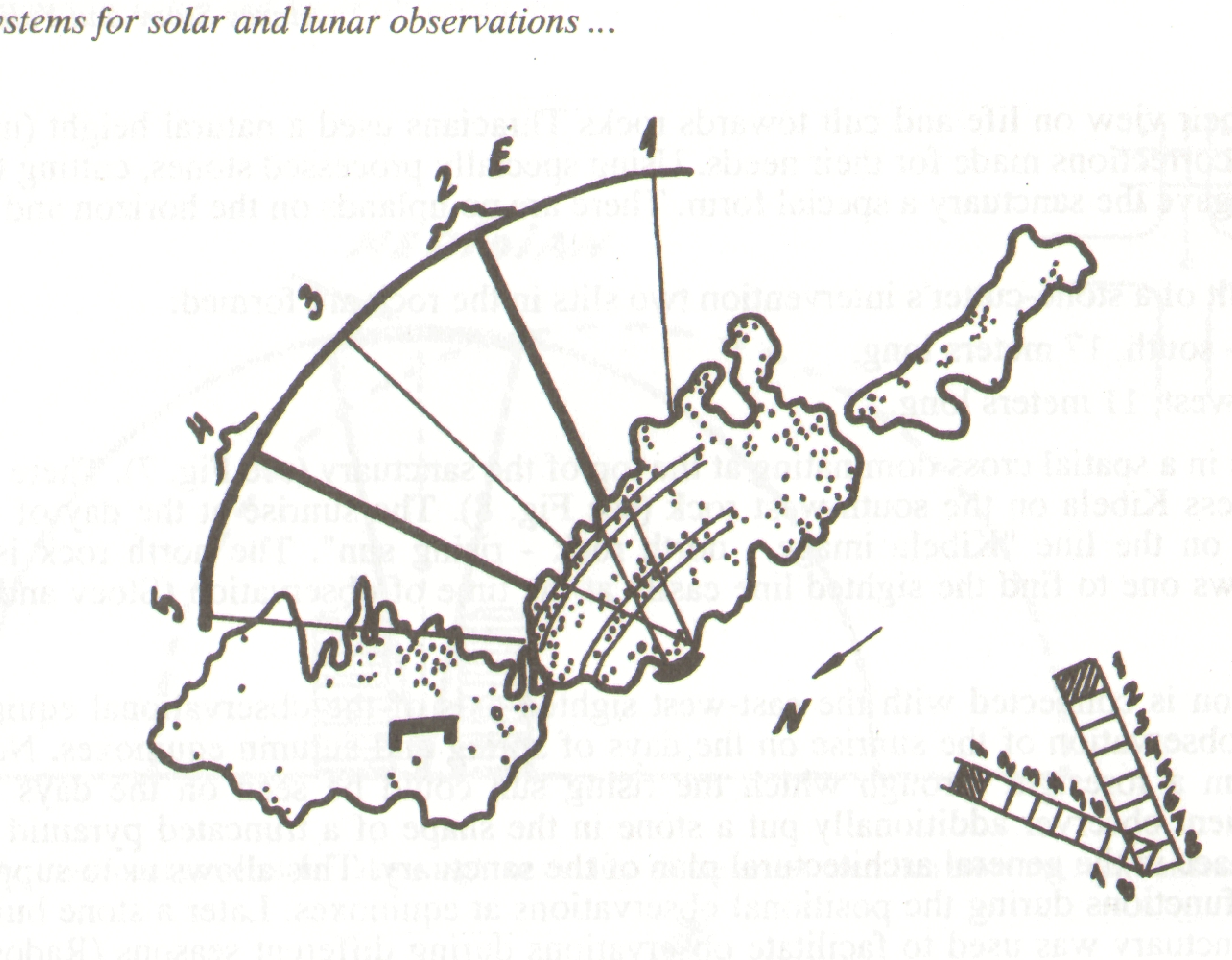

Figure 5. Radial section of the rock sanctuary central part and characteristic target directions for observations (1, 3 and 5 - sectors outside the astronomically significant directions, 2 - spring and autumn equinox, 4 - summer solstice).

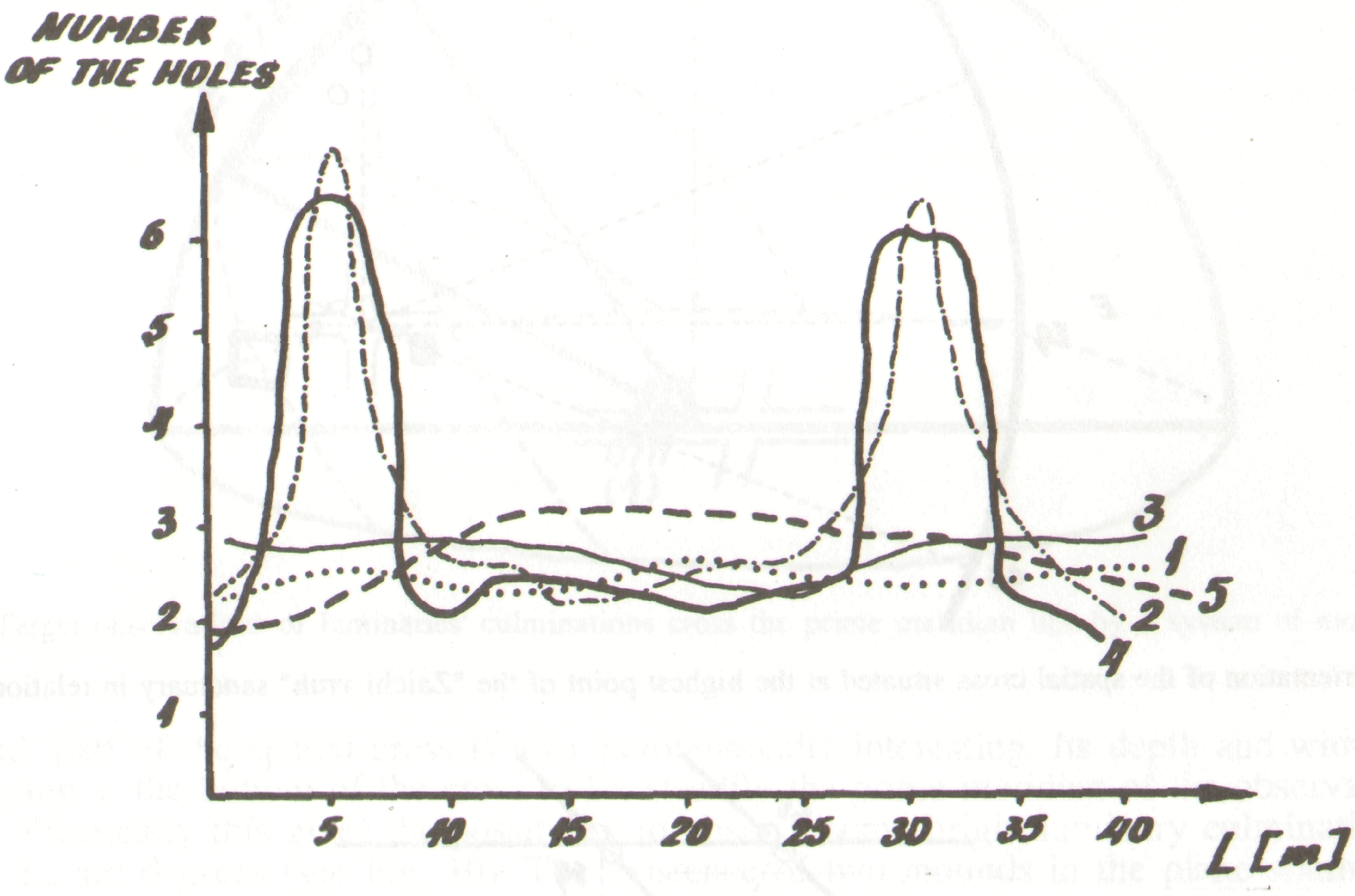

Figure 6. Histogram of the densities of the hollows situated at different target directions.

The other archaeoastronomical object is the Thracian rocky sanctuary "Zaichi vruh" situated on the territory of the Early Hellenic town of Kabile (Sasselov 1986) which was very important in the political history of the tribe Odrisi (IV-III cent. BC), and in the whole economic and historical development of Thracia (Najdenova 1982). The existence of rocky images at the sanctuary suggests that a long time ago the local population regarded the rocks as a holy place and different cult rituals were completed there. Archaeological investigations show that the earliest cult centre at Kabile was on the acropolis. At the very beginning the rock itself was honoured, after that the rocky images, and in the end the cult was connected with the rocky hill itself. Probably at that time a cult building at the west side of the sanctuary was built. Today one can see only its foundations.

True to both their view on life and cult towards rocks Thracians used a natural height (unique in the region) with some corrections made for their needs. Using specially processed stones, cutting the rock and its surface, people gave the sanctuary a special form. There are no uplands on the horizon and its height is practically 0°.

Thus, as a result of a stone-cutter's intervention two slits in the rock are formed:

a) north - south, 17 meters long;

b) east - west, 11 meters long.

They are made in a spatial cross dominating at the top of the sanctuary (see Fig. 7). There is a stylized image of the goddess Kibela on the south-west rock (see Fig. 8). The sunrise at the day of the summer solstice is sighted on the line "Kibela image - north rock - rising sun". The north rock is artificially leveled which allows one to find the sighted line easily at the time of observation (Stoev and Varbanova 1994).

The east horizon is connected with the east-west sighted axis of the observational equipment. This axis was used for observation of the sunrise on the days of spring and autumn equinoxes. Northeast and southeast rock form a foresight through which the rising sun could be seen on the days of equinox. Moreover, the ancient observer additionally put a stone in the shape of a truncated pyramid which does not have its own place in the general architectural plan of the sanctuary. This allows us to suppose that the stone had defined functions during the positional observations at equinoxes. Later a stone building at the west part of the sanctuary was used to facilitate observations during different seasons (Radoslavova and Stoev 1991). It has been calculated that the moments of equinoxes were determined with an accuracy of ±1 day (taking into account the geometrical size of the trench and the distance to the local horizon).

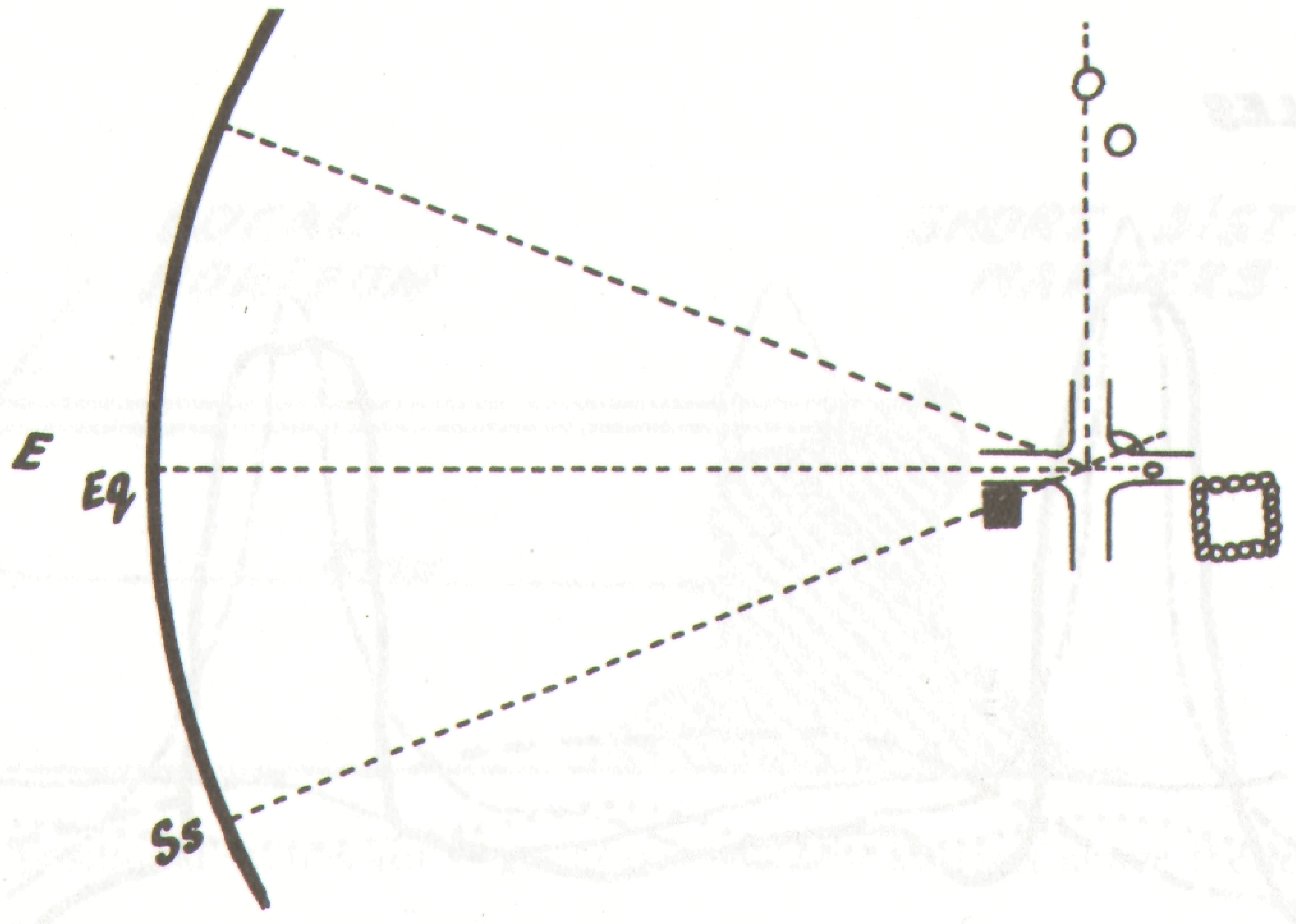

Figure 7. Orientation of the spatial cross situated at the highest point of the "Zaichi vruh" sanctuary in relation to the local horizon.

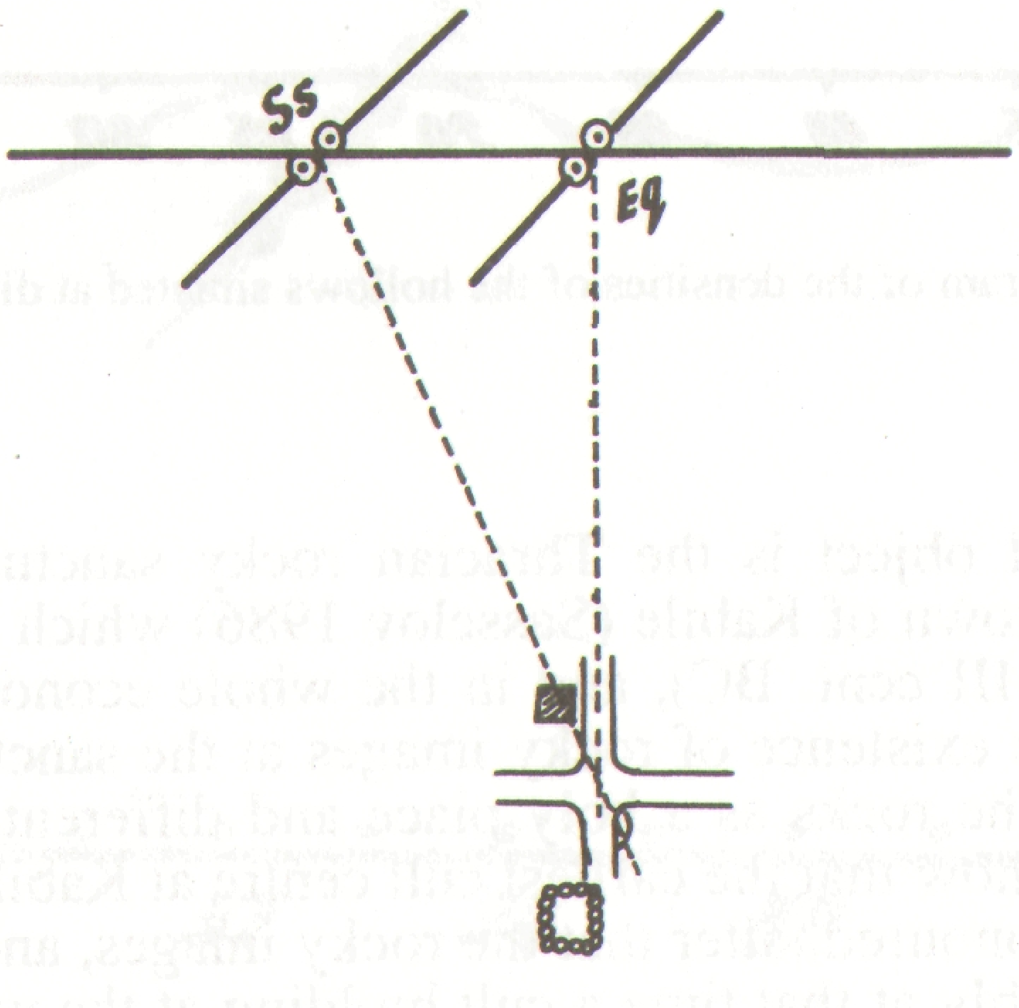

Figure 8. Sunrise on the day of the summer solstice and illuminating of the image of the goddess Kibela by the first solar beams

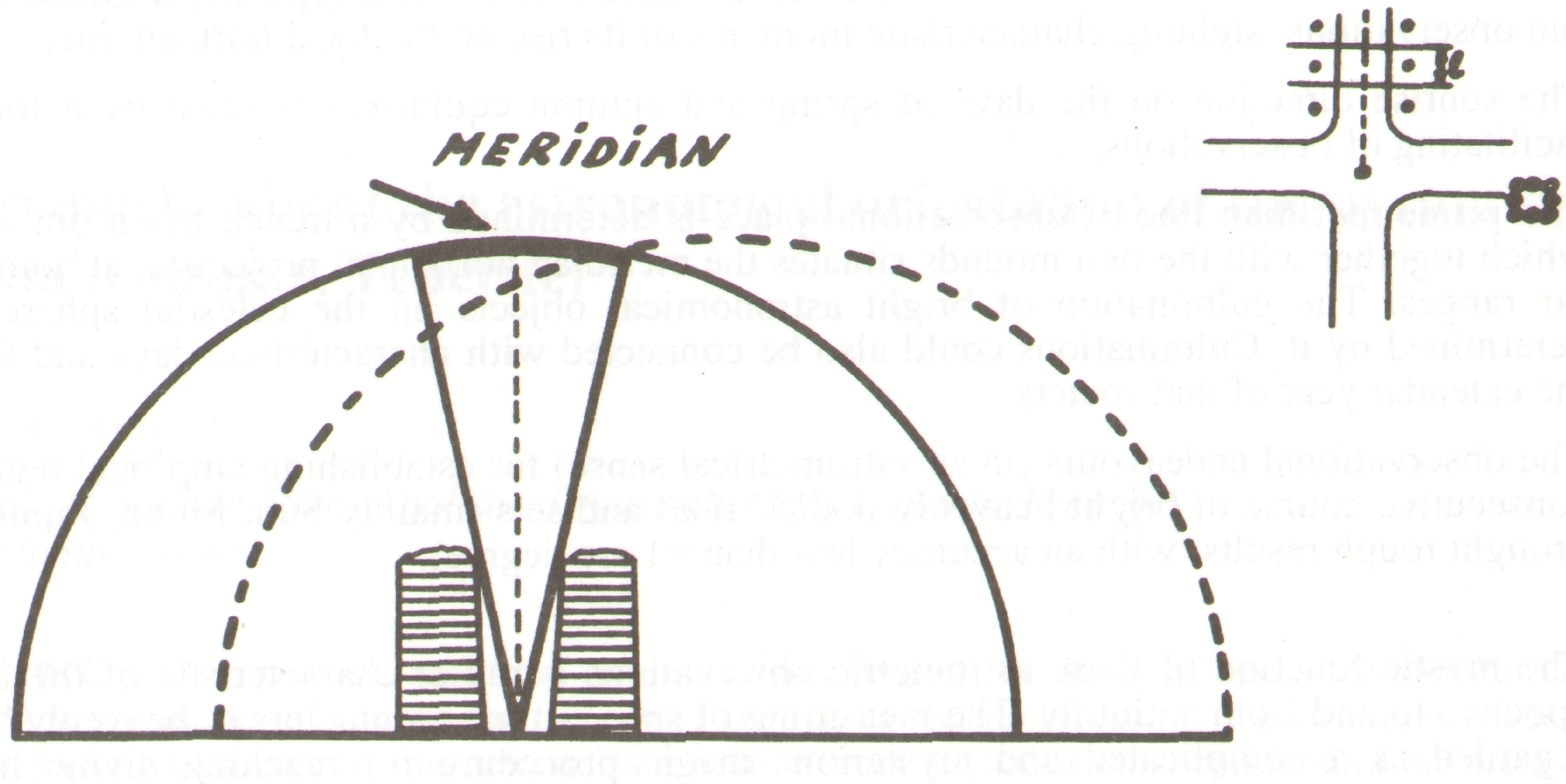

Figure 9. Positional systems for taking sight at the line of the prime meridian from the rock sanctuary "Zaichi vruh"

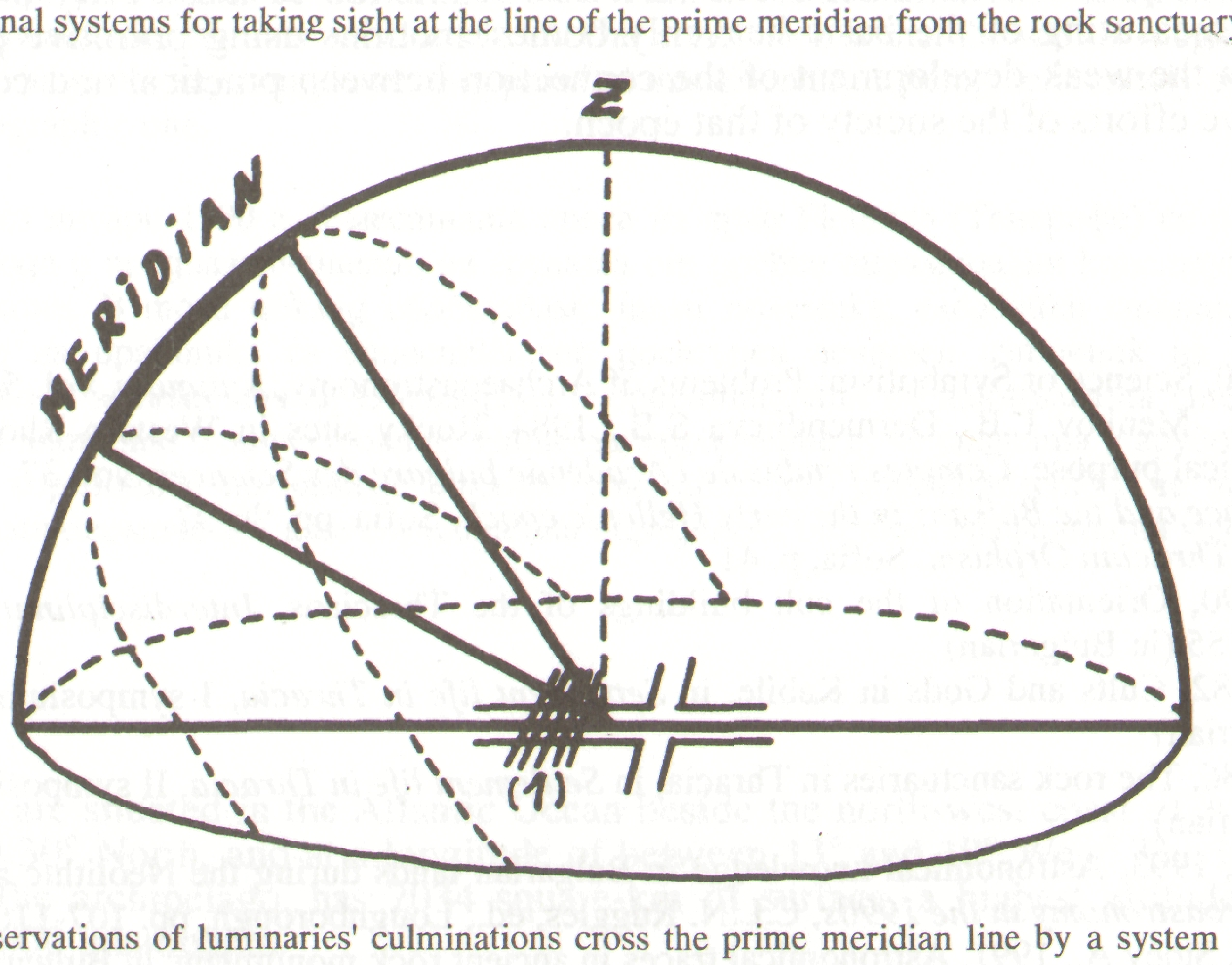

Figure 10. Target observations of luminaries' culminations cross the prime meridian line by a system of movable stops of the sight (1).

The south part of the spatial cross is also astronomically interesting. Its depth and width allow the observer staying at the bottom of the cross to fix steadily the prime meridian of the observational place (see Fig. 9). Practically this gives the possibility to observe some bright luminary culminations with an accuracy of ±2 arc degrees (see Fig. 10). The existence of two mounds in the plane southward of the sanctuary situated on prime meridian horizontal projection shows that they were connected with the observational procedures at the sanctuary. Probably they facilitated the observer's positioning in the meridian plane during the day but at nighttime fires were used to facilitate their being found. On these mounds a lot of wood ash has been found. Calculations based on the data about the trench geometry and angular dimensions of some bright luminaries show that the upper culmination of the objects could be defined with an accuracy of ±1 arc degree.

The following conclusions could be drawn from the above considerations:

1. The studied rocky sanctuaries in southeast Thracia and the Central Rhodopes are characteristic representatives of this type of archaeoastronomical objects situated on comparatively high rocky places.

2. The two Thracian sanctuaries are ancient solar observatories devoted to the cults of the Sun, the Goddess Kibela, and Sabasii.

3. In an architectural-situational plan the studied sanctuaries show a typical positional system for sun observations, sighting characteristic moments of its rise on the local horizon line.
4. The sunrise direction on the days of spring and autumn equinoxes is fixed by a foresight for facilitating of observations.
5. The prime meridian line of observational place is determined by a trench hewn out of the rock which together with the two mounds situates the meridian horizontal projection at both close and far ranges. The culmination of bright astronomical objects on the celestial sphere could be determined by it. Culminations could also be connected with characteristic days and feasts from the calendar year of that society.
6. The observational endeavours (in an astrometrical sense) for establishing empirical regularities in consecutive course of bright heavenly bodies' rises and sets (mainly Sun, Moon, Jupiter, Saturn) brought rough results (with an accuracy less than ±1 arc degree).

The mystic function of these astrometric observations is rather characteristic of these and later epochs - to and from antiquity. The measuring of space - time parameters of heavenly bodies was regarded as a complicated and mysterious magic procedure for reaching divine insights by enlightened priests-astronomers. The historical restriction of these early observational methods and the measuring of the basic heavenly bodies' motions using primitive positional systems is based on the weak development of the connection between practical and cognitive forms of the subjective efforts of the society of that epoch.

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The dissemination of the ancient astronomical knowledge of Slav peoples in the Middle Ages Europe

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Abstract. In the early Middle Ages Ancient Greek Science continued to be kept in many Byzantine theological books. In the IX-X century Natural Sciences and Astronomy in particular from the works of Ancient Greek scholars passed in theological books of one of the heads of the Bulgarian state Christian church - Joannes Exarch. Because his books were written in the Cyrillic alphabet and understandable in the Slav peoples' Ancient Bulgarian language, they were dispersed among some Slav peoples.

The historical reasons for the creation of Joannes Exarch's books, some of their astronomical contents, their dissemination among Serbian and Russian peoples and the importance of this is discussed briefly.

The paper I would like to present is not an archaeoastronomical one. But I am in a position to present at least two arguments.

Firstly, archaeoastronomy is the beginning of the history of astronomy; my paper deals with the epoch approximately immediately following that beginning.

Secondly, our conference is taking place in a country with long history and I suppose every participant is curious to learn something of that history, especially of the history of astronomy, not just archaeoastronomy.

Резюме. През ранното Средновековие много византийски богословски книги продължават да съхраняват древногръцката наука. През IX - X в. естествените науки и астрономията в частност преминават от работите на древногръцките учени в богословските книги на един от водачите на българската християнска църква - Йоан Екзарх. Тъй като неговите трудове са били написани на кирилица и на разбираемия за славяните старобългарски език, те били разпространени сред някои славянски народи.

Накратко се дискутират историческите причини за създаването на книгите на Йоан Екзарх, тяхното астрономическо съдържание, разпространяването им сред някои сръбски и руски народи и важността на този процес.

Докладът не е археоастрономически, но мога да изтъкна поне два довода в полза на неговото представяне.

Първо, археоастрономията е началото на историята на астрономията; а в доклада ми се разглежда епохата, която почти непосредствено следва това начало.

Второ, нашата конференция се провежда в страна с дълга история и предполагам, че всеки участник е любопитен да узнае нещо от тази история, особено от историята на астрономията, а не само на археоастрономията.

Introduction

The IV century for Europe is characterized with the separation of the Eastern part of the Roman Empire, Byzantium, and with further increasing strength of Christianity, granted as an official religion in Rome since 311. After the doom of the Western part of the Empire in 476, a long period began in Europe called "the Dark Middle Ages". Concerning scientific meditations, apart from lack of necessity, one of the reasons for this darkness was the conceptions of Christian theology at that time - the discouraging of any attempt or even desire to know more about the world than is written in the Bible.

Some different ideological and cultural situations dominated Byzantium, where Christianity coexisted with unforgettable ancient Greek and Hellenic scholars and philosophers and their works. It is well known that the principal works of those men had been translated in the ancient Arabian state (the first

translation of Ptolemy`s Megalie Syntaxis from Greek to Arabic was made in 829) and scarcely after that were moved to Western Europe and retranslated from Arabic. Thus translated, ancient works were considered by historians of science to be practically the sole sources of the ancient natural sciences for non-Greek speaking European peoples in the Middle Ages, but not before the XIII century. In this paper we claim to show another, and at times earlier, source of astronomical knowledge among Slavic-speaking peoples in Europe - the books of one of the heads of the Bulgarian Christian church in the IX-X century, Joannes Exarch.

Brief historical notes

Bulgaria - the native country of Joannes Exarch was officially established by a Byzantine pact in 681. The new state was situated at the North frontier of Byzantium. In 855 Cyril and his brother Methodius composed the Slav alphabet. In 868 Slav literacy was acknowledged by Pope Adrian the Second.

In 865 prince Boris, the Sovereign of Bulgaria, accepted Christianity as the official religion of his state and after some negotiations with the Roman Catholic Pope and with the Patriarch of the Byzantium church, the Orthodox variant of this religion was accepted.

The new doctrine had to be popularized and disseminated among the people. An important need arose: books on Christianity which are understandable by Bulgarians, who in their majority consisted of the indigenous Slav population. This was the duty of the patrons of the new church. One of them was Joannes, the Bulgarian exarch, who lived in the IX-X century. The sources for the books were the Byzantium theological works.

Ancient scholars in Byzantium

While in Western Europe shortly after the XIII century, Albertus Maggnus (1193-1280), in Germany, and his student Thomas Aquinas (1225-1274), in Italy, had incorporated the Aristotelian geocentric system, Byzantine theologists had accepted the ancient scholars a long time before. As early as the VIII century Joannes Damascinus had written about the six days' creation of the world by God. In the IX century the famous Byzantine scholar Photius, the Patriarch of the Byzantine Orthodox church in Constantinopole, maintains the thesis that the ancient philosophers and scholars had the mission to build the road for the Christian doctrine. One of the students of Photius - Michael Psellos - already included in the Orthodox theology many ideas from ancient authors, but especially the geocentric conception of Aristotle and Ptolemy.

The works of Joannes Exarch and his personality

The author, who "discovered" Joannes Exarch and his work in science is Kalajdovich (1824) in the first half of the XIX century. Except several relatively short church sermons (Ivanova-Mircheva 1971), Joannes left to us two books: Theology or "Bogoslovije" in the Slav language, which in Russia had been known with the heading "Nebessa", i.e. Sky (Gorsky & Nevostruev 1852; Theology... 1877), and Hexameron or "Shestodnev" in the Slav language.

Theology is a translation which Joannes began in 884-85, concluded Georgiev (1962; 1968), to half of the ancient Slav-Bulgarian book "On the orthodox faith" by Joannes Damascinus. This book was written in the middle of the VIII century and is a relatively concise exposition of the essential Christian dogmas in the interpretation of that Byzantine theologian.

The second book interprets - in the manner of similar Byzantine composition - Moses's tale of the creation of the world by God in six days. "Shestodnev" is a compilation from several Byzantine theological books on the same subject. But, as Joannes Exarch mentions himself, he added many reflections of his own. A part of these additions concerns some philosophical and naturalistic (including cosmological) conceptions of ancient Greek scholars, mainly that of Aristotle (Joannes Exarch 1971).

Joannes Exarch is undoubtedly one of the famous, not only Bulgarian, but Slav literate in the early Middle Ages. But for the absence of documents, we had to reconstruct his personality on the basis of what we can extract from his works.

The composition titled "Shestodnev" characterizes its author as an excellent philologist, who perfectly masters the language from which he translates, and the one in which he writes. His book shows him also as a splendid theologian, and as a magnificent philosopher and naturalist, for his time. The wide learning from Byzantium theologians as well as ancient authors shows Joannes as an encyclopedist who undoubtedly was one of the most educated men in south-eastern Europe for this remote time.

Astronomy in the works of Joannes Exarch

Since Joannes Exarch was one of the most pronounced clerical persons in the IX-X century new church in Bulgaria he persuaded people that Christianity was the sole genuine faith and preached the biblical doctrines scrupulously and in detail. But arguing about the gospel, he widely used ancient Greek scholars' conceptions. Since the main subject in both his books is the creation of the world, Joannes often exposes their cosmology and other connected astronomical problems, as well as a lot of other knowledge from natural sciences. In the following below we would like to present some examples of the astronomical knowledge that Joannes exposes in his above cited books. The citations in parts A and B are my translations in English from two books in Bulgarian noted with (1) and (2) respectively (Joannes Exarch 1971 and Kristanov & Dujcev 1954).

A. Heavenly bodies' forms and movements

Joannes Exarch drastically disagreed with the biblical view on the Earth form. He accepted Aristotle's view that the Earth is a globe. Moreover - he argues with authors such as Cosmas Indicopleustes, who asserts that the Earth is flat. It is interesting to note that Joannes does not use Aristotle's arguments for the globular form of the Earth. He exposes only the indirect argument about the Moon form. He explains that if it were not round it would not be able to exhibit its phases: "And if the Moon is made thus it is obvious that the other stars have round form" - concludes the literate man (1, p. 165) in his Hexameron. As usual at that time by "stars" he meant the Sun, the Moon, the planets, and the Earth too. So as in Aristotle, to whom Joannes referred, the Earth as well as the planets has a spherical form.

In Hexameron Joannes Exarch reasons about the size of the heavenly bodies. In the words for the fourth day of the creation he explains: "Certain men, who had learned astronomy thoroughly, say that the Sun is many times larger than the Earth itself and the earthly globe is two times greater than the Moon" (1, p. 143). Further he announces that the circle of the Earth is 252 thousand stades and its diameter - more than 80 thousand stades. With one Greek stade equivalent usually to 157.5 meters, it equals more than 12600 km. Taking into account that Aristotle in his "Heaven" accepts the Earth circle to be around 400 thousand stades, it is evident that Joannes has taken the dimension determined by Eratosthenes, who lived after Aristotle, in the III century BC.

The movement of the Moon and the Sun is described in detail in Joannes's books. "The Moon...every month passes through the 12 Zodias" (2, p. 71). In Hexameron it is specified that this round lasts about 27 days and 1/3, i.e. about 27 days and 8 hours, and that the Moon's movement is retrograde. The visible movement of the Sun is retrograde too. Joannes Exarch in detail checks on the Sun's passages through the Zodiac constellations telling the intervals it remains in every one of them, taking the bound dates from Joannes Damascinus (2, pp. 69-70). This movement of the Sun Joannes Exarch connects with the seasons. In addition he clarified that the earthly globe circles around itself and on the part illuminated by the Sun it is day while on the opposite one it is night.

The knowledge of the Sun's movements and their periods allowed Joannes to explain the Moon's calendar and its differences in comparison with the Sun's.

At the end of this section we would like to mention that the Bulgarian writer says that the knowledge of the Sun's and Moon's movements allows "the eclipses of the great lightened objects, i.e. the Sun and the Moon, to be predicted and explained many years beforehand" (1, p. 156). The coming of a Moon's eclipse Joannes elucidates as follows: "An eclipse of the Moon is caused by the shadow made of the Earth, when the Moon...is rendered itself at the opposite side...Then the Earth produces a shadow and the Sun light does not reach it, in order to light up the Moon, thanks to that it is eclipsed" (2, p. 73).

B. Cosmology in the works of Joannes Exarch

The relation of Joannes Exarch about the world's creation is restricted of course to the frames of the Bible; eight centuries had to elapse to arrive at the idea of the formation of the Solar system without the

obligatory resort to God, as Buffon and Kant did. But when someone deals with the creation of the world it would be at least desirable to describe what this would represent, i.e. - in contemporary terms - to touch the cosmological aspect of that question. Joannes widely involved this matter in his books.

As usual at that time Joannes knows five planets: "...seven planets exist: the Sun, the Moon, Jupiter, Mercury, Mars, Venus and Saturn", he said (2, p. 61) not differing between planets themselves and the Sun and the Moon. What the planets represent, he explains: "The planets in reality are stars but they call them sailing" (1, p. 155).

All heavenly bodies go round the central Earth in circles, often named by Joannes "belts". There exist "seven circles on which seven stars are situated" (1, p. 97). It is necessary to note that the order of disposition of the planets around the Earth in Joannes Exarch's cosmology differs from the order in Aristotelian theory. While after Aristotle the Moon together with the Sun is nearest to the Earth, Joannes Exarch places Mercury and Venus after the Moon and then the Sun. In this notion the Bulgarian scholar exposes a point of view which is something intermediate between the Aristotelian theory and the conception of Pitagore's school.

At the end of this section it is interesting to mention the unfavourable, in respect to astrology, aspects of the books of Exarch. Announcing the adopted opinion that "through the rise, the set and the combination of the stars with the Sun and the Moon all our acts are guided", he argues that this never means "because being endowed by God with a free will we are masters of our acts" (2, p. 71).

Diffusion of Joannes Exarch's works among Slav peoples

The importance of Joannes Exarch's works is not only a considerable contribution to the initial steps of Bulgarian theology, literature and natural sciences. Their main significance arises from the diffusion of the two books of the distinguished priest among some of the Slav peoples: being spread among peoples they served as means for their education. The two theological books had been placed up in the scientific learning of a vast part of the Slav intelligentsia in the early Middle Ages.

The earliest known copy of "Hexameron" is from 1263. It was transcribed by a Serbian monk named Theodore Gramatic. From the XII-XIII century is the first known copies from "Theology", now in Russia. Later on - in XIV-XVII centuries several new transcriptions had been made. Another five copies of "Hexameron" from XV-XVIII centuries are known too. Except, there are some indications (Shamatov 1900; Levochkin 1984) that some of Exarch's works are used in the "Izbornik", which means "Selection" of the king Svjatoslav Jaroslavovich in Kiev's Russia, whose book is dated in 1073.

Therefore probably as early as the XI century but not later than XIII, one of Exarch's works penetrated and became known among East and south-east Slav populations. The diffusion of his books and/or parts of them was a significant phenomenon for the natural sciences and the learning of Slav peoples in Europe in these distant times. Taking into account that Arabic translations of Ptolemaic work did not enter Russia (Bronshten 1988) - at least at that time - Joannes Exarch's books were the principal sources for astronomical and natural scientific knowledge for Slav nationalities in the early Middle Ages.

Conclusion

The brief description of the two books of the Bulgarian scholarly church man from the IX-X century, Joannes Exarch, gives evidence that, parallel with theological convictions, he also propagated a lot of astronomical knowledge from ancient Greek authors. Transcriptions of these books have been disseminated among Slav populations other than Bulgarian such as Russian and Serbian in XI and early XII centuries. Thus in these populations a different atmosphere, in comparison with the enlightened atmosphere of Western Europe, was formed in the early Middle Ages. Consequently the generalization of the thesis of "Dark Middle Ages" for Europe as a whole is wrong. As early as the XI-XIII centuries in Eastern Europe and in the Balkans in south-eastern Europe there existed a corner with a certain astronomical culture. Except Byzantium some Slav peoples - Bulgarian, Russian, Serbian - entered this region.

Unfortunately an unenviable historic lot reached these peoples in the following times. The Bulgarians were under the Byzantine yoke from the early XI up to nearly the end of the XII century. After the middle of the XIV the Turkish invasions of the Balkans began. By the end of this century, all the Balkan nationalities fell under the several - centuries - long Turkish yoke, which devastated lands and settlements, destroyed the accumulated culture, literacy and science, and stopped development for

centuries. As for the Russian people, they suffered not only from invasions of barbaric tribes with a consequent yoke from XIII century, but from divorces and discords between a great number of governments formed on the territory of contemporary Russia to end only in the middle of the XVI. All that history caused Western Europe peoples to gain great priority not only in economic, but in spiritual development.

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Hunting the European Sky Bears: when Bears ruled the Earth and guarded the Gate of Heaven

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Abstract. The two Sky Bears, Great Bear and Little Bear, have been classified as belonging to the most archaic strata of the star figures known to European peoples. It has been assumed that once upon a time scenes portrayed by certain other star figures were associated with some half-forgotten sky text. Although previously, in Europe, no archaic set of stories connected to the Sky Bears had been clearly identified, extensive field work over the past twenty years in the Basque region has allowed me to discover the existence of a cycle of stories and related ritual performances dealing with the adventures of an archetypal hero, Hartzkume, the Bear Son (linked symbolically with both Ursa Major and Ursa Minor), and his encounters with a series of celestially encoded beings. Variants of these stories and similar ritual practices are found throughout Europe.

In this paper I allege that certain star figures familiar to Europeans, constellations which are primarily non-zodiacal in nature and clustered for the most part in the southern sky, were invented to illustrate the actions of the hero and the spirit animals that accompanied him on his ritual journey, and, in this fashion, to facilitate the collective retelling of the tales. Linked to bear ceremonialism, the cycle of stories and related ritual practices form a type of *Bildungsroman*, revealing time-factored activities and sky-texts with a strong shamanic flavor. Cross-cultural cognitive parallels from North America indicate that the hero's adventures fit a scenario not unlike that of the Native American vision quest with its animal helpers and medicine bundle. Similarly, in Europe, there is evidence that the archetypal quest experience, embedded in the sacred stories, was externalized collectively by being projected conceptually onto the stellar screen and acted out ritually in song and dance.

Резюме. Двете "небесни мечки", Голямата Мечка и Малката Мечка, са класифицирани като принадлежащи към най-древната група звездни фигури, известни на европейските народи. Приема се, че някога сцени, изобразявани чрез други звездни фигури, са били свързвани с някакъв полузабравен небесен текст. Въпреки че по-рано в Европа не е била ясно идентифицирана никаква древна група от предания, свързани с небесните мечки, обширната полева работа през последните двадесет години в страната на баските ми позволи да открия съществуването на цикъл от предания и свързани с тях ритуални представления, отнасящи се до приключенията на един архетипен герой, Харцкуме, Синът на Мечката (символично свързан както с Голямата Мечка, така и с Малката Мечка), и неговите срещи с ред същества, присъстващи на небето. Варианти на тези истории и подобни ритуали са открити в цяла Европа.

В този доклад твърдя, че определени звездни фигури, познати на европейците, съзвездия предимно незодиакални, разположени в по-голямата си част на южното небе, са били очертавани, за да илюстрират действията на героя и животните, които го придружават в неговото ритуално пътешествие, и по този начин да улеснят колективното преразказване на приказките. Свързан с мечата обредност, цикълът от истории и сродните ритуали формират вид *роман в картини*, разкриващ действия, зависими от времето, и небесни текстове със силни шамански нотки. Сравнителните паралели с култури от Северна Америка показват, че приключенията на героя следват доста сходен сценарий с този на *търсенето-епопея* при коренните жители на Америка с животни-помагачи и лечебна торбичка. По същия начин, в Европа има свидетелства, че на архетипното *търсене*, запечатано в свещени предания, е бил даден колективен външен израз чрез концептуалното му проектиране на звездния екран и ритуалното му претворяване в песни и танци.

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Comets as a prototype of St. Michael the Archangel's fiery sword in the Bulgarian iconographic tradition

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Abstract. A lot of examples can be given by mythology of God's weapons whose prototypes are easily recognized among astronomical phenomena (meteors, meteorites, comets). In the Christian tradition the notion of St. Michael the Archangel is often connected with his sword - a symbol of retribution and the fight against evil. Norling was the first to suggest that comets are the prototype of St. Michael the Archangel's fiery sword. Some logical arguments which confirm this opinion are quoted. The XIX century was the end of the Bulgarian Renaissance. It was a period of time when many churches were built and decorated by several painting schools. Two ways were established of how St. Michael the Archangel was to be drawn. The first one - with an ordinary sword, and second one - with a fiery sword. The correlation between the appearance of the brightest comets and paintings with the fiery sword is demonstrated on the base of our catalogue of St. Michael the Archangel's icons. A new method for dating the icons using the bright comets' passages is proposed.

Резюме. Могат да се дадат много примери от митологията за оръжието на божествата, чийто прототип лесно се разпознава сред астрономическите явления (метеори, метеорити, комети). В християнската традиция представата за Св. Архангел Михаил често се свързва с неговия меч - символ на възмездието и на борбата срещу злото. Норлинг пръв предполага, че кометите са прототип на огнения меч на Св. Архангел Михаил. Изтъкват се някои логически аргументи, които потвърждават това мнение. XIX век е краят на българското Възраждане. Това е период, през който са построени много църкви, изографисани от художниците на няколко школи. Установени са два начина за изобразяване на Св. Архангел Михаил. Първият - с обикновен меч, а вторият - с огнен. Връзката между появата на най-ярките комети и рисунките с огнения меч се доказва на базата на нашия каталог на икони с образа на Св. Архангел Михаил. Предложен е нов метод за датиране на иконите чрез използване на появата на ярките комети.

Introduction

In 1989 we were surprised by an unexpected coincidence. The icon "St. Michael the Archangel defeats the devil" (Fig. 1), drawn in 1881, had been painted during the time when a bright comet was observed. The uniqueness of this icon is connected mainly with St. Michael the Archangel's fiery sword which was proved by us is an image of the comet (Nedialkov 1990).

According to the literature available to us, G. Norling was the first scientist to offer the hypothesis that comets are the prototype of St. Michael the Archangel's fiery sword (Kovshun 1990). He explained the occurrence of "the angel with fiery sword" to King David as the recurrent return of the Halley's Comet in 1010 BC.

We shall put forward possible logical arguments confirming this thesis.

In the first place, we have to note that all sky objects were deified in the remote past. The nature of the comets, meteors, meteorites and bolides was not distinguished clearly then. For example, according to Hindu mythology, comets are the tail of the dragon Don-tga-Rahu slaughtered by Vishnu, who prevents the theft of the sacred liquid amrit. Very often bright meteors or bolides had been described as "fiery dragons with smoky tails" (Ipatiev's chronicle 1215). According to M. Bekert, the first iron objects used by humans were made from meteoritic iron. The words "iron" and "heavens" are similar in the more ancient languages. Widely spread was the worship of sacred stones, most of which were meteorites.

Like the comets whose appearance had been always assumed as an omen, some of these stones were used to forecast the future.

In the second place, a lot of examples can be given for God's weapons whose prototypes are easily recognized not only among terrestrial phenomena (storms, lightning) but also among astronomical phenomena (meteors, meteorites, bolides, comets). In the Hindu epos Indra throws fiery spears to the dragon Vritra. The Scandinavian god Torh crashes the stone ball, thrown by the giant Runge to obscure the Sun, and as a consequence a stone rain spreads over the whole Scandinavian peninsula (Meletinskiy 1990).

St. Michael the Archangel is mentioned four times in the Scripture: twice in Dan. (10. 13 ff. and 12. 1), where he is represented as a helper of the Chosen People; once in Jude (v. 9), disputing with the devil over the body of Moses, and once in Rev. (12. 7-9), fighting the dragon. In this connection the great captain St. Michael the Archangel was early regarded by the Church as the helper of Christian armies against the heathen, and as a protector of individual Christians against the devil, esp. at the hour of death, when he conducts the souls to God. He is a personage with a wide presence on the icons. Though comparatively rare, his sword is depicted made of fire, just like a flame.

According to Bulgarian beliefs up to the middle of the XIX century, the Sun, the Moon and the stars altogether were in one and the same sky. The stars hung like candles downwards (Georgieva 1983).

There are several similarities between the comets and St. Michael the Archangel's fiery sword. The first one is the coincidence of shape and colour. The flames of the swords remarkably resemble the tail of a comet. On the other hand, it is known by the history of astronomy that comets themselves were associated in people's minds with bloody swords (Nikolov et al. 1986). It is not occasional that the fiery sword is red. Their functions are close to each other, too. The sword of St. Michael the Archangel is a symbol of retribution and death, just as comets forecast destruction and death. And, at last, both comets and swords have a fiery nature. But even after Ticho Brahe, who proves in 1577 that comets are cosmic objects, Aristotle's hypothesis - that so-called fiery phenomena (comets, aurora, shooting stars and the Milky Way) are not part of the "perfect" heavens - survives till the beginning of the XIX century. During the same historical period a lot of naive beliefs can be found in the common consciousness.

Figure 1. Vasil and Todor Genkovi brothers, "St. Michael the Archangel defeats the devil" (1881), The Church of St. Paraskeva in the village of Peterniza.

A short description of the inner development of the Bulgarian icon painters will be given. They all were people who believed in God. Their drawings not only followed the rules of the Erminees but also followed the Scripture. They knew that skies were not only created to mark the days, months and years, but also to prompt the omens. Since God takes care of everybody and everything, he takes care of the omens, too. The angels ("messengers", "executors of the God's will") appeared from the heavens. The comets appeared in the skies to let the people know about the future. Something more, according to Kozma Indicoplevst, whose opinion was valid in the Middle Ages, "not only the Sun and the Moon, but all sky objects are ruled, and they are moved under the action of the God's will. The same angel's power causes the rain, brings the clouds together, rules the winds, the snow, the heat and the cold" (Flamarion 1872). It's obvious that these points of view were known by the painters, especially by those who got their crafts in a monastery.

At the same time the painters knew that the Scripture expressed their thoughts in a double sense. They knew that the Scripture contained secrets beyond human understanding and the imperfection of human nature was the reason that the angels appear to us as a visual substance. Then it's not amazing that the star of Bethlehem has been considered to be either mythical, or a miraculous object beyond the bounds of scientific explanation, or a real astronomical phenomenon (Humphreys 1991). As Dionisius Areopagitis (IV century) wrote "no one need doubt that the visibility was used to indicate the invisibility". Bulgarian painters possessed a deep knowledge both about the sky and heavens. They had to contemplate the sky with their material (external) eyes and heaven - with their immaterial (inner) eyes. So their creative works connected the imperfect and the perfect heavens (Trubetskoy 1991).

Following this logic the same thoughts can be applied to the word "fiery". At last, many passages in the Scripture can be given as examples for comets, shooting star rains and bolides.

The data and the method

The XIX century was the end of the Bulgarian Renaissance. It was a period of time when many churches were built and decorated by several painting schools. It was natural to us to continue our research using a sample of a larger number of icons.

We aimed at checking the time coincidence between the appearance of the brightest comets and the paintings of St. Michael the Archangel with the fiery sword.

During the period of the collecting of iconographic material we used 52 albums and books, exploring the Bulgarian icons. 86 images of St. Michael the Archangel were found - 61 icons, 18 mural paintings and 7 stamps. 41 icons have been dated (from 1614 till 1885), as well as 15 mural paintings (from 1493 till 1882). The total number of images with a fiery sword is 9, distributed as follows: 7 icons, among them 5 dated from 1785 till 1885, and 2 mural paintings with one dated to 1811.

On the base of this sample a catalogue was made on cards. This catalogue contains the most important characteristics of the icons. The information about each icon includes the title, the date, the author, the origin, place of conservation, right (left) hand of the archangel, the presence of a sword, the position and angle of the sword, geometry, the other hand of the archangel, the face foreshortening, and the reference.

We compared the icon datings to the moments of bright comets passing, using for that purpose the "Catalogue of Ancient and Naked-Eye Comets" (Hasegava 1990). Then we estimated the possibility of accidental coincidences if we accept the condition that the passage of bright comets and the painting of fiery swords were independent events.

The results

Three main topics can be found in the icons of St. Michael the Archangel. The first one is "St. Michael the Archangel", usually an icon from the first row of the iconostasis; the second - "St. Michael the Archangel squeezes the life out of the rich man" and the third one - "The conclave of archangels". In all cases St. Michael the Archangel holds the sword in his right hand. In the first and the third design the sword is held nearly vertically, ready for a strike. In the second design the sword is directed down towards the sinner. In his left hand he holds a manuscript, or the soul of a dead man, or together with St. Gabriel the Archangel they hold a sphere with Jesus Emanuel's image on it.

Icons with fiery swords can be found in all the above mentioned designs. The flames can be easily recognized not only geometrically, but also by the colours - in all cases the red color predominates.

The comparison of the dated icons with the list of Hasegava (1990) shows many coincidences - 13/41, which is 10 times more than the expected coincidences - on the condition that these events have been independent. A higher level of coincidences - 4/6, is reached if we restrict ourselves only to the icons and mural paintings with fiery swords. We shall note that the probability for accidental coincidences here is ten times smaller. Figure 2 shows how the visual magnitude of the naked-eye comets changes in the course of time. The dated icons and mural paintings with fiery swords are marked by bells. The statistics show that mainly the brightest ($< 2^m$) comets have been observed. Comets with higher magnitudes have been observed too (up to 5^m).

Let us describe the dated images with fiery swords. The eldest (1785) is the "Conclave of the archangels" from the church of the Assumption, in the town of Sliven. The brightest comet during the last ten years has a fourth magnitude.

The part from the icon "St. Michael the Archangel with eight life scenes", a masterpiece of Papa Vitan Junior from Trjavna, was drawn in 1811, the year when an exclusively bright (0^m) comet passed. There is a mural painting from this year, the fresco "Out of the Paradise" in the church "Shroud of the Holy Virgin" at the Hermitage of the Rila monastery, drawn by Toma Vishnov.

There is no coincidence between the icon "Conclave of the Archangels" from the church of St. George in the village of Lubenova Mahala, drawn by the brothers Vasil and Todor Genkovi in 1879, and the appearance of any bright comets.

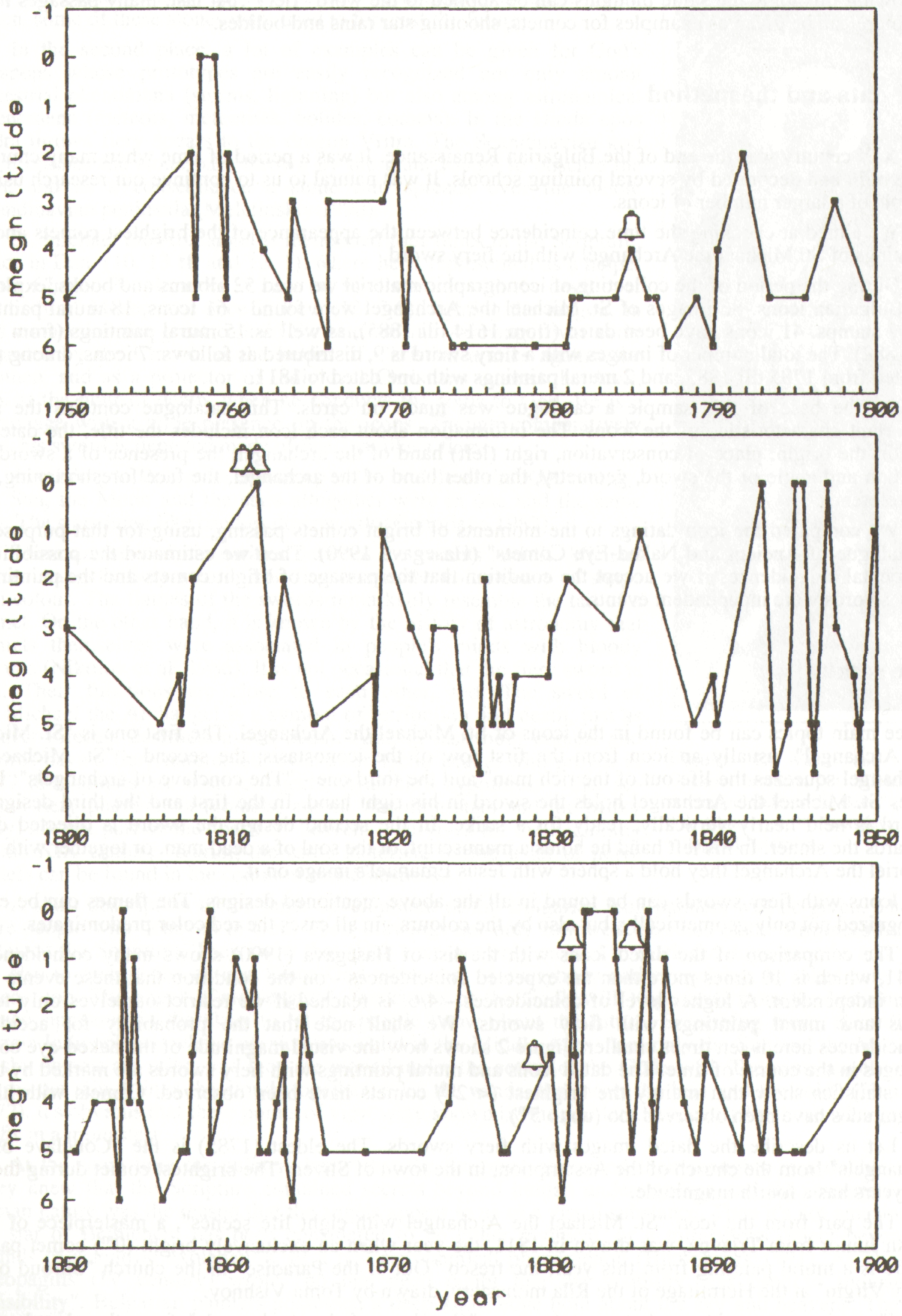

Figure 2. Variance of the visual magnitude of the naked-eye comets within time interval 1750-1800, 1800-1850 and 1850-1900. Bells indicate dated icons (and mural painting in the time interval 1800-1850) with fiery swords.

The icon "St. Michael the Archangel defeats the devil" at the church of "St. Paraskeva" in the village of Peterniza in the region of Pleven, was drawn in 1881, the time when a bright comet (1^m) had passed. Here we notice a puzzle hidden by the painters. The fiery sword is held in his left hand. An unrealistic geometry of the sword reveals the image of a comet. The unique design shows that possibly a "non-corrected" version of Gundo Rennie's composition is drawn (Bozhkov 1986).

The last icon, "St. Michael the Archangel", from the church of the village of Indzhe voivoda, drawn in 1885 by G. and D. Minevi brothers, is painted just after three bright comets have passed for the three years till 1884.

Discussion

Now we are ready to offer a new method for dating the icons, using comet passages as a chronometers. To be more effective, it is necessary to have an icon which is not precisely dated (± 5 years) and to have only one bright comet for this period of time.

Unfortunately we could not apply this method to our icons because they all were very badly dated (± 25 years) and there were too many bright comets in these time intervals.

One circumstance decreases the accuracy of our method - the painters could draw their icons having the past passages of the bright comets. For example, Giotto drew his great fresco "Magi Pay Homage to Jesus" at least 2 years after he saw Halley's Comet of Halley in 1301.

Conclusion

1. We confirm the hypothesis of G. Norling that the fiery sword of St. Michael he Archangel has the comets as its prototype.
2. The correlation found between the appearance of bright comets and the depiction of St. Michael the Archangel with a fiery sword brought us to suggest a method for dating these types of icons.

In the near future we would like to increase the total number of the icons and to check our conclusions on the iconographic material with other orthodox sources.

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Aeneolithic astronomical observations and mythological beliefs

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Abstract. Man at the end of the Aeneolith possessed a wide range of "scientific" knowledge whose application spread over all spheres of his activity. Amazingly the broadest knowledge is in the field of what we today call astronomy. It is connected with complete or partial observation of the sky, the big luminous bodies, the bright stars and certain constellations, which helped him to make comparatively precise calendar systems.

The logical assumption is, that astronomical knowledge has been preserved and handed down in and among the representatives of the high priest class. Rock sanctuaries were used as observatories to perform astronomical observations. According to fragmentary data 22 sites of this kind, situated in the Eastern Rhodopes, started functioning during the late Aeneolith.

The Aeneolithic cult centre, near the village of Dolnoslav, Plovdiv district, is related to the same period. It consisted of 22 temples devoted to different deities, and some of them to the moon and sun. The complex of a few temples located near the main one form a group devoted to the birth, growing up and setting of the sun. An exquisite relief discovered in the main temple building allows us to assume that the inhabitants of our lands during the late Aeneolithic period divided the year into three, and not four seasons. Also from the excavations of the temple centre near Dolnoslav, we determined that the supreme god, respected by the prehistoric man, was the one who controlled time, or Time God. Right after him and on equal level in the prehistoric pantheon lined up the Moon and Sun Gods.

The results from the excavations near the village of Dolnoslav show that a big part of the Ancient Greeks' myths, connected with celestial bodies, were created during the prehistoric epoch in the lands of Central Balkans. According to what we have discovered so far, these myths find their material expression at the end of the Aeneolithic period.

Резюме. Човекът от края на каменномедната епоха е разполагал с широк диапазон от научни познания, чието прилагане практически е обхващало всички сфери на неговата дейност. Изумително е, че тези познания са най-големи в областта, която днес наричаме астрономия. Свързани са с цялостни или частични наблюдения на небесната сфера, на големите небесни тела, на ярките звезди и на определени съзвездия. Задълбоченото познаване на пътя на големите небесни тела, звездите и съзвездията са му помогнали при изработването на сравнително точни календарни системи.

Логично е предположението, че астрономическите познания са били съхранявани и предавани от представителите на висшето жреческо съсловие. За извършване на астрономически наблюдения като обсерватории са били използвани скалните светилища. По непълни данни двадесет и два обекта от този вид, разположени в Източните Родопи, са започнали функционирането си през късната каменномедна епоха.

Към същото време се отнася и енеолитният култов център, разположен до с. Долнослав, Пловдивско. Състоял се е от 22 храма, посветени на различни божества, а някои от тях - на луната и слънцето. Комплексът от няколко храма, разположени около централния, образуват група, посветена на раждането, възмъжаването и залика на слънцето. Изящна релефна композиция, открита в централната храмова постройка, ни позволява да приемем, че късноенеолитните обитатели на нашите земи са разделяли годината на три, а не на четири сезона. Пак от разкопките на храмовия център до с. Долнослав установихме, че върховен бог за праисторическия човек е бил богът, контролиращ времето или богът Време. Непосредствено след него и на еднакво ниво в праисторическия пантеон се нареждали обожествените луна и слънце.

Резултатите от разкопките до с. Долнослав показват, че голяма част от митовете на древните гърци, свързани с небесните светила, са били създадени през праисторическата епоха в земите на централните Балкани. Те намират материалния си израз като релефни изображения едва в края на енеолита.

The necessity of counting time accompanied prehistoric man for millennia of his development. It was equally important for the social groups inhabiting all parts of the earth, irrespective of the geographical and climatic peculiarities of the respective regions. At least for the last 8000 years BC a large number of various calendars were known and with their help prehistoric man counted the passing of time. Having in mind the complex character of the production activities of the inhabitants in various regions or even only in certain settlements, we can certainly suggest that each of the calendar systems must have been bound with others in such a way that it could be used at the same time by farmers, cattle breeders, hunters, merchants and even craftsmen. Considering the various calendar systems and binding them only with periods of pure agricultural and cattlebreeding activities is inapplicable to the prehistoric epoch.

Speaking about prehistoric man having inhabited our lands, we have to determine whether he had enough knowledge to create an approximately exact calendar system that could best serve his needs. This question arises because of the poor attention paid by science to this aspect of the practices of prehistoric man. A detailed discussion of this problem would take a lot of time and space and so we will confine ourselves to counting only some top achievements in applying knowledge in various areas. One of them is making skull trepanations (Boev 1972) by means of primitive tools made of flint, stone and copper. In the field we call now geometry, we can point out as an achievement the planning of squares, triangles, rectangles, trapezium, etc. of sizes from several centimetres to tens and hundreds of metres. The same figures were successfully inscribed in circles and ovals. Inscribing a pentagon in a circle or a rectangle in an oval even today is a very difficult thing for most people but prehistoric man knew how to do this.[1] It is curious, that the Aeneolithic inhabitants of our lands knew that a regular circle or an oval can be drawn by connecting many straight lines.[2] Discovering the three metals - copper, gold and mercury (Raduncheva 1992) - at the same time, is a top stage of the development of human knowledge.

During the different stages of discovering and enriching ores to produce desired objects, knowledge of the nature of the phenomena was applied skilfully. An epoch marking discovering was the use of mercury in amalgamating copper crucibles and in obtaining liquid gold paints (Raduncheva 1992). But what most surprises us is the almost perfect knowledge of prehistoric man connected with the observation of the sky, of the large sky objects, of the bright stars and of certain constellations. The possibility of projecting them - relatively exactly upon round objects (what is the case with the clay spindle whirl found in the settlement near Slatino village, Kyustendil district (Tchohadjiev 1989a), suggests serious mathematical knowledge, as well as knowledge about the nature and form of the sky cupola and the earth globe. Anyhow, the Great bear and the swan constellations were projected on the right places exactly on an object that was round and spun. All that has been said up to here, confirms the wide scale of varied "scientific" knowledge of prehistoric man. In this sense, that excellent knowledge about the sky, about the paths of the sky objects, about stars and constellations establish him quite logically as a good astronomer, and suggests skill in developing a suitable calendar system.

A logical question arises as to whether all individuals of society had access to the knowledge mentioned above. Having in mind the complicated hierarchy of the social system, the answer should be "no". As it was in all early societies, "scientific" knowledge was a privilege accorded to the priests and was taboo for the greater part of the population that inhabited our lands. It guaranteed the domination of religious power over civil. Priests were those who had the right to a final decision. They had the right to decide when and how the accumulated and handed down knowledge should be applied to predict natural phenomena, motions of sky objects, etc. The activity of priests was carried out in strict ritual forms which provided the opportunity for obtaining exact scientific results. They chose definite places where exactly fixed ritual practice was conducted. Rock sanctuaries (Raduncheva 1990), situated high in the mountains, were used for rituals connected with astronomic observations. We know that 22 rituals practised in the Eastern Rhodopes have their beginning in the 4th millennium or at the end of the Aeneolithic period. Every ritual action was expressed in the form of a ritual mythological story. The main sky bodies were personified and anthropomorphized. They were placed on the highest stage of the complicated hierarchical stage of the scale of prehistoric pantheon. In this connection we have got most detailed data from the excavations of the Aeneolithic cult centre near Dolnoslav village[3] and from different objects found in various places of the country.

1 The statement is a result of the archaeological study of the Aeneolithic temple center near the village of Dolnoslav, Plovdiv district.

2 Unpublished observations of the constructions of the stone fence (enclosing belt) of the Aeneolithic temple center that existed near the village of Dolnoslav, Plovdiv district.

3 Unpublished results from the archaeological excavations near the village of Dolnoslav, Plovdiv district.

The Aeneolithic cult centre near Dolnoslav village is situated amongst the highlands at the foot of the steep slopes of the Eastern Rhodopes. The cult centre is visible from the Belantash rock sanctuary. The two sites were functioning simultaneously during the Aeneolithic and no doubt, they are linked in character and meaning. While high up in the mountains observations of heavenly bodies were taking place, down in the cult centre religious ceremonies were being carried out to explain to the pilgrims what was going on up in the mountains. The temples in the cult centre were richly supplied with bas relieves, usually telling about the lives and actions of gods. The complex consists of 22 temples dedicated to different gods but we will only discuss some of them.

A very finely made relief was discovered in the main temple building placed in the highest central part of the complex. It represents a sitting woman holding two small children on her knees. On her left side is a snake taking away a third child. The snake's head was put at the opening of a hole leading under the ground. The woman's face was painted in red, expressing sorrow. In the next panel of the same relief, high above the level of the described composition, there is a man's figure wearing a crown of three snakes. He holds a sceptre of two more snakes in his left hand. We have grounds to interpret this relief as symbolising the development and the repetition of the annual cycle. Here a prehistoric priest is telling us that the mother-year has three children - the seasons. The snake-animal conveys the semantic meaning of a mediator between people and gods and among the gods themselves as well, and illustrates the passing of time taking the seasons away into non-existence. After fulfilling its dedication, the snake returns to the crown of the GOD TIME in order to come down through his hands and to take away the next season. The personified image of the year as a woman was meant to symbolize the reproduction taking place at the end of the annual cycle. We learn two things from this unique relief: that the prehistoric inhabitant of our lands used to divide the year into three and that the supreme god respected by him even now we can call God Time. That belief and the rituals connected with it were of great importance to the people, since the relief was included as a component of a complicated machine which provided sound effects during the ceremonies. Such equipment is unique. TIME, which controlled the passing present and the coming future was surrounded by a suite of chosen beasts and certain heavenly bodies. In our case it is the SUN. The temples attached to the central temple were dedicated to this topic - conception, birth, growing up and closing the annual cycle. The leopard, the snake and the adult sun played the main roles in those temples. The SUN image faced the Belantash rock sanctuary, which at the same time functioned as a solar observatory (Stoev et al. 1990). The idea of counting three seasons was supported by the round calendar found in Dolnoslav (Stoev and Stojtchev, in press). Reading the calendar, it was discovered that one of the seasons was missing.

The division of the year into three seasons can have another explanation. One should forget that the earliest Neolithic discovered in our lands was a migration event for the Central Balkans. In the following millennia several migrations took place, most probably northwards. The newcomers reaching our lands brought and further developed their rich culture, including their way of counting time. So we think that the idea of dividing the year into three originated in regions where three seasons existed. However, these could be regions belonging to the Mediterranean basin. So it is possible that summer was divided between late spring and early autumn. From the point of view of archaeology and history, various suggestions can be made. Only astronomers can make the final decision and choose the right conclusion.

The relief discussed above as materialization of a mythological story, connected with a global religious idea, was of such importance, that it passed in a modified form into the later antic religion. The mythological story of Persiphone says that when Hades kidnaps her into his underground kingdom and marries her, her mother Demeter weeps over and grieves for her lost child (Batakliev 1989). That is the time when life dies so that it may revive again when Persiphone comes back to stay with her mother. This fact is an example of how the global idea of TIME born at the beginning of human history survived in the millennia.

The idea of heaven and heavenly bodies - MOON and SUN - was developed in three temple buildings, too, situated in the North-western periphery of the cult centre near Dolnoslav. Those are two rectangular temples connected by a round building between them. The round temple was placed between the horns of a huge bucrania and it was dedicated to the MOON. It was formed by three concentric circles dug into different depths. A triangular screen wall was made around the central circle. A large anthropomorphic image of the MOON was placed at its top. It was a circle with a diameter of 0.65 m. The face has only two eyes. The moon was placed at the top of the screen wall, as if it embraced the central gap. At its bottom, a huge bull's horn was found. The whole image faced north against a relief image of a sun riding on a fish. It was made on the floor of the north temple building which was connected with the round temple by means of a large bucrania. The two images of heavenly bodies face each other and are precisely diametrically placed. The fish carrying the sun swims westwards (Raduncheva in press). In the same direction there was a second similar composition with smaller

dimensions. Unfortunately, the second one reached us in very bad condition. It is obvious that a definite moment was fixed when the SUN and the MOON were following their paths in the sky. The passing, shrinking sun to the West gives up its place to the night God - the MOON. As it is placed in the round temple, one has the impression of motion in a horizontal circle around the earth. In these two buildings there is also a mythological story. Most probably it gives information about a certain day when the full moon and the sun are in a certain position. Of great importance to the formation of religious concepts is the fact that over 6 thousand years ago man believed that the moon was pulled in the sky by bulls and the sun by a huge fish - animals having nothing to do with heaven. This idea comes to us from the deep past and has continued its existence in the religions of various peoples in later epochs. For the first time we meet a bull in the sky in the frescoes discovered in the Neolithic town of Çatal Huyuk in Asia Minor (Mellaart 1967). Ancient Greeks believed in it too. They thought the Goddess of the Moon, Selene, was pulled in a coach by bulls. We also know that the Egyptian god Apis carried a moon disc between its horns. In just the same way the moon temple with the moon inside is placed between the horns of the large bull's head in Dolnoslav. A model of a temple discovered in the settlement near Slatino village, Kyustendil district (Tchohadjiev 1989b), dates back to the first half of the Aeneolithic period. An anthropomorphic image of the sun in a beautiful boat being pulled by two groups of three oars was drawn with graphite on the floor of the temple (Tchohadjiev 1989b). Amongst the various kinds of gold objects found in the "gold" necropolis near Varna, were discovered some gold pieces which can be interpreted as symbolising the golden sun boat (Ivanov 1989). The idea that the sun from its sunset travelled to Ethiopia - its rise place in a boat, passed during the millennia into the beliefs of the Ancient Greeks. Ancient Egyptians, however, believed that the sun travelled by a sun boat. In the temple south of the round one, the main motif tells us about gods rising towards the stars, carried by a strange animal with a head of a bull with something like a beak. Its body was huge, with solid-hoofed legs that resembled those of a horse. It was mounted by two riders and it was represented at a moment of flight upwards and southwards. There is a bright yellow lunar disc above the composition. For the time being it is difficult to say which part of astronomy these images are connected with. They seem to be quite logically connected with the everlasting idea of man united with eternity through the ever-living god TIME. It should not be excluded that the mythological story presented here tells about the return of spirit of the past year to its creator - the god TIME - so that it could begin its recycling. All this scene is observed from an altar by a snake - the mediator between people and gods and among the gods themselves.

All this makes it clear that heaven was deeply respected by prehistoric man. It was inhabited by almighty natural events personified as gods. Man did not have to disturb them in order to be blessed by them. This explains why man, having lived at the end of the Aeneolithic, did not act aggressively towards the sky. We know that in very rare cases birds were hunted. The bones of birds are rare finds and they belong to only several kinds of swans - dumb and singing. Some kinds of geese were hunted too for the needs of religious rituals. If we remember that the Ancient Greeks deeply respected the god Uranus (the sky) married to the goddess Gaea (the earth) giving birth to Cronus (The TIME) we will understand the depth of the roots of Greek mythology in the prehistoric period.

In the end we will leave the strange world of the gods to understand the importance of practical astronomical observations for the fate of whole societies and even of civilisations. There is evidence that the cult centre near Dolnoslav was set on fire and deserted forever by its own inhabitants in the months of May - June. It was proved during of excavations that before the fire the cult centre had been carefully destroyed. Every detail of the altars was broken off and left there. After this sacrifices were made at the altars - three dogs, three lambs, a pig and a young individual. Only after that were the buildings set on fire. Three or four months were needed for this to be done. If, in the spring equinox, during the astronomical observations on celestial bodies, bright stars and constellations, prehistoric priest-astronomers registered a certain star configuration compelling him to stop any activity, he obeyed the celestial sign. Slowly and systematically he destroyed and deserted the greatest cult centre in Europe dedicated to celestial bodies. After that moment, all rock sanctuaries stopped functioning. That was the moment when the inhabitants of 90% of the settlements set their centuries - old dwellings on fire and deserted them forever. Vast areas of the Balkan peninsula were deserted for a period of more than seven hundred years. There is not satisfactory answer to the question: "what was the fate of the population, and in what direction did it disappear?". Thus comes the end of a glorious epoch. We can only suggest that the withdrawal of the population from the central Balkan peninsula destroyed its society and social structures. Spreading in various directions, it was not able to preserve its own material culture in the way known to us. Maybe, accepting the way of life of the newly discovered communities, they kept in their memory their old spiritual tradition. This explains the existence of certain idols' type on the Mediterranean islands in the bronze age. They resemble the Aeneolithic ones found on the Central Balkan peninsula. All kinds of temple models known in our lands for millennia BC are also known on the Mediterranean islands and the coastal regions of North Africa in the bronze age.

More than a millennium and a half later, the observatories on places nominated as rock sanctuaries received their new pilgrims but it was for a short period of time at the end of the late bronze age. Only the classical Thracian population in our lands converted the same places into sites of worship. They hardly had the same meaning as that in the late Aeneolithic. These arguments can show us how serious knowledge in the field of astronomy embodied in a religious ritual form can decide the fate of a whole civilisation.

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Calendar in the Cult Scene from Ovcharovo

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Abstract. I present results from the study of an Aeneolithic find known as the Cult Scene from Ovcharovo. Based on mathematical, astronomical, and semantic analyses of the signs on the plates, termed "altars", it is shown that a calendar interpretation of these is possible.

The grouping of these signs according to their natural arrangement shows that, by simple arithmetic operations, it is possible to obtain calendar-astronomical units. The semantic analyses gives additional support to the hypothesis that a system for time reckoning is present.

The results allow to be concluded that the level of mathematical and astronomical lore in the Aeneolithic society has been surprisingly high. This can only be explained by assuming that complex, long-term periodic events have been observed and recorded since very ancient times.

Резюме. Представят се резултати от изследването на енеолитната находка, известна като Култова сцена от Овчарово. Въз основа на математически, астрономически и семантичен анализ на знаците върху плочките, наречени "олтари", се показва, че е възможна календарната им интерпретация.

Групирането според естественото им пространствено разположение показва, че чрез елементарни аритметични действия е възможно образуването на конкретни календарно-астрономически единици. Семантичният анализ допълнително подкрепя хипотезата за наличие на система за отчитане на времето.

Резултатите позволяват да се заключи, че в енеолитното общество нивото на математическите и астрономическите знания е неочаквано високо. Това може да се обясни само ако се приеме, че сложните и с голяма продължителност периодични явления са наблюдавани и фиксирани от най-дълбока древност.

Introduction

The problem of penetrating the world of ancient societies is complex and inexhaustible. Evidence for their culture are mostly archaeological finds that have survived through time, which range from the huge megalith and architectural complexes to the miniature decorations and cult objects. Their complex analysis, as well as the reconstruction of their meaning and use, allow for the understanding of the unique "language" of the otherwise speechless artefacts. Some confirmation of the reliability of the interpretations can be derived from ethnographic as well as written sources.

An important place in those studies is occupied by the archaeoastronomical hypothesis. A large accumulation of data irrefutably shows that already in ancient times people have observed and recorded astronomical events. Discussions today concern mostly the specific knowledge and the practical skills for obtaining them.

Calendars from more distant or more recent times are a unique key to many questions.

It has been found that many bone objects from the Palaeolith of Siberia and West Europe, as well as cave drawings from the Mesolith, contain records of astronomical cycles. Important contributions to the study of these most ancient of the calendars and the creation of a methodology for researching, have come from A. Marschak and V. Laritchev.

Using many examples, Marschak (1964, 1972) proves that on such Palaeolithic finds are recorded lunar cycles. The number of signs used is equal or proportional to the synodic period of the Moon,

whereas their shapes, sometimes literally and sometimes symbolically, represent the changes of the lunar phases.

Analysing objects of Palaeolithic art by means of the exact sciences, Laritchev (1987, 1989, 1993) manages to broaden the study perspective of the most ancient calendars. He believes that the complex patterns of countable signs on objects with very different shape and purpose carry certain astronomical information. He shows that, by discrete numbers ("number blocks"), basic calendar periods such as lunar months, solar and eclipse years are constructed, and finds, in the spiral-like ornaments, information about the complicated tracks of the "wandering" stars and the frightful solar and lunar eclipses. Laritchev pays attention to the total number of signs which in many cases happens to be directly or indirectly associated with the cycle of eclipses - the Saros. He suggests that larger eclipse cycles have also been used to serve as a kind of a Great Year commensurable with different astronomical periods.

Many of the results confirm already known features of the old calendars, but many still turn out to be very surprising. A confirmation is received of the differing, mythological perception of time and space by the ancient people, as well as of the peculiar allegory of the means of expression used, which is why it is difficult and not always possible to interpret the signs calendar-wise directly. The fact emerges that, with the use of a minimum number of signs and their skilful spatial arrangement, the sacred lore can be recorded or "coded". To this type of lore belongs also the knowledge of important biological cycles which shows that the calendar has been a means for solving important problems in farming and household life. Frolov (1974, 1977) pays attention to the signs on the female decorations from the Palaeolith. He interprets the records on bracelets, proportional to the pregnancy period of woman, as "an archaic form of primitive calendar". As he notes (1974: 117), "time was the most difficult to be counted visually or on the fingers of one's hand, it was precisely the time count that required a graphical recording".

The counting of many objects or sequence of days, months and years makes mandatory the use of signs. They naturally lead to the abstract idea of the number as a measure of a certain quantity. Counting or leaving uncounted, as well as the adding or leaving out of pre-fixed signs are operations corresponding to the mathematical acts of addition and subtraction. In this way, the study of signs on finds from the Paleolith often leads to specific conclusions about the astronomical as well as the mathematical knowledge and skills in those times.

Unfortunately the examples are comparatively few. Only those carried by materials impervious to decay and occasionally surviving the course of time, have reached us.

In the last decades in Bulgaria remarkable monuments from the Neolith and Aeneolith (VII-V millennium BC) with a possible calendar-astronomical interpretation have been found. These are signs and images on cult objects (Todorova 1972; Tchohadzhiev 1984), in caves and rock sanctuaries (Gerasimova, Stoytchev and Stoyev 1991). These studies fill some gaps in the available scanty data about the astronomical knowledge in the period between the Palaeolith and the Bronze Age. The aim of this work is to present one of these missing links, namely the Calendar in the Ovcharovo Cult Scene (Fig. 1).

Description and history of study

The Cult Scene from Ovcharovo is one of the exceptionally rare archaeological finds that have reached us intact. It was found and first studied by H. Todorova (1972, 1976, 1983) during the excavations of the settlement mound near the village of Ovcharovo, Targovishte district, in Northeast Bulgaria. It was found under the remains of a dwelling in the fire-swept horizon IX [1]. The radiocarbon method dated the find to 3760 +/– 60 BC, and the calibration of this result places the artefact in 4500 BC (Kovatcheva 1983). It belongs to the Kodzhadermen-Gumelnitsa-Karanovo VI culture. It has been suggested that it represents a model of the complete interior of an existing cult temple. The scene contains 30 clay objects covered with kaolin and richly ornamented in red ochre.

The various signs comprising the ornamentation - lines, concentric circles and rectangles, spirals, a cross, a triangle, and angles, are considered as universal calendar and astronomical symbols. Not accidentally, therefore, Todorova also interprets them as schematic lunar, solar, plant, and animal images (1972, 1976: 26-27, 1983: 91-92). The most enigmatic are the three plates, 3 to 4 cm high and 0.3

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[1] H. Todorova notes (1983, p. 22, 37, 96) that the fires that have completely devastated the dwellings in horizons VIII, IX, and X, have not been an exceptional occurrence. Fire is the reason for the destruction of all synchronous horizons of the nearby setlement mounds, which is hardly coincidental. Possibly devastating (military?) conflicts are to blame. It is interesting that the life of the settlement from horizon IX has been only 9 years, as determined by the number of the layers of clay mixed with chaff, plastered upon the floor of the dwellings (Todorova 1983, p. 24, 25).

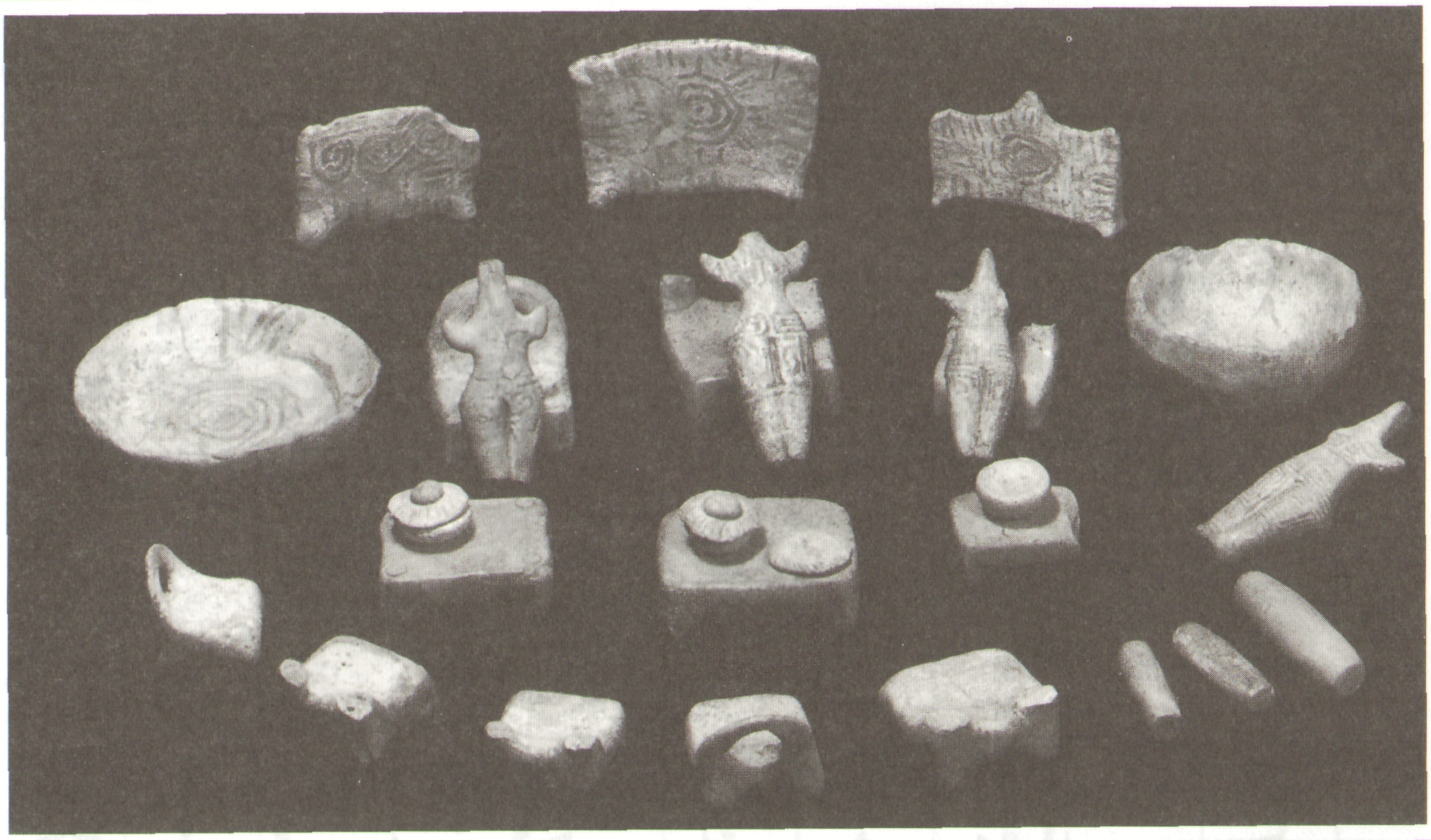

Figure 1. A general view of the Cult Scene from Ovcharovo (The photograph is from the archive of National Museum of History).

to 0.5 cm thick, which Todorova names altars; she suggests that they symbolize the homes of three gods: of nature's powers (I), of the Sun (II), and of the Moon (III), in a "trinity" cult much more ancient than the find itself (1972: 67). According to her, the short lines on the edges of these plates are not just an ornament, since there is neither rhythm nor symmetry in their arrangement. They could be a count of cycles, for example days, under the sign of each of the three gods. Todorova (1983: 92) states: "If this is so, then we have before us the oldest calendar system in our lands, [...] related to the needs of the early agriculture".

The first results from the study into the signs of the altars (Koleva 1986, 1991; Nikolov 1991) confirm the hypothesis that a calendar had been in use in the Aeneolithic settlement near Ovcharovo.

My interpretation is based on the sketch (Fig. 2) made from a photograph and with additional details sketched in after a personal examination of the find. Details which are well preserved or can be restored with certainty, are drawn in solid line. Signs which are missing from the restored or non-restored areas but can be regarded to have existed with high likelihood due to a certain logic in marking, are drawn in dotted line. Dotted areas denote coloured spaces (usually at the upper or lower corners of the altars). A possible reconstruction of the missing left-hand tip of altar I is the addition of two signs, drawn in dotted lines, one to the right edge of side A and one to the upper edge of side B.

A detail in the inner left part of side E has been severely damaged due to crashing. In schemes of different authors it is treated differently. The seven lines to the left of the two concentric circles are connected in a plant ornament (Todorova 1972, 1983; Nikolov 1991), or are presented as separate groups: one of three horizontal, and two pairs of two vertical lines situated under each other (Koleva 1986, 1991). The remains of paint speak in favour of the latter treatment due to their well marked horizontal and vertical arrangement (the connecting of lines into angles is usually done at sharp angles, as seen in altars I and II), and also due to the similar way of situating of the vertical lines to the right of the circles.

The locally broken entirety of the artefact gives some indefiniteness to the interpretation. It enhances the ambiguity of the results and the polyvariancy of the conclusions, which is typical for reverse problems.

That the three altars belong to the Cult Scene, are manufactured by similar technique, and have similar appearance and symbols, makes it possible to study them separately as well as together. The here presented data give additional grounds for a unified calendar-astronomical interpretation.

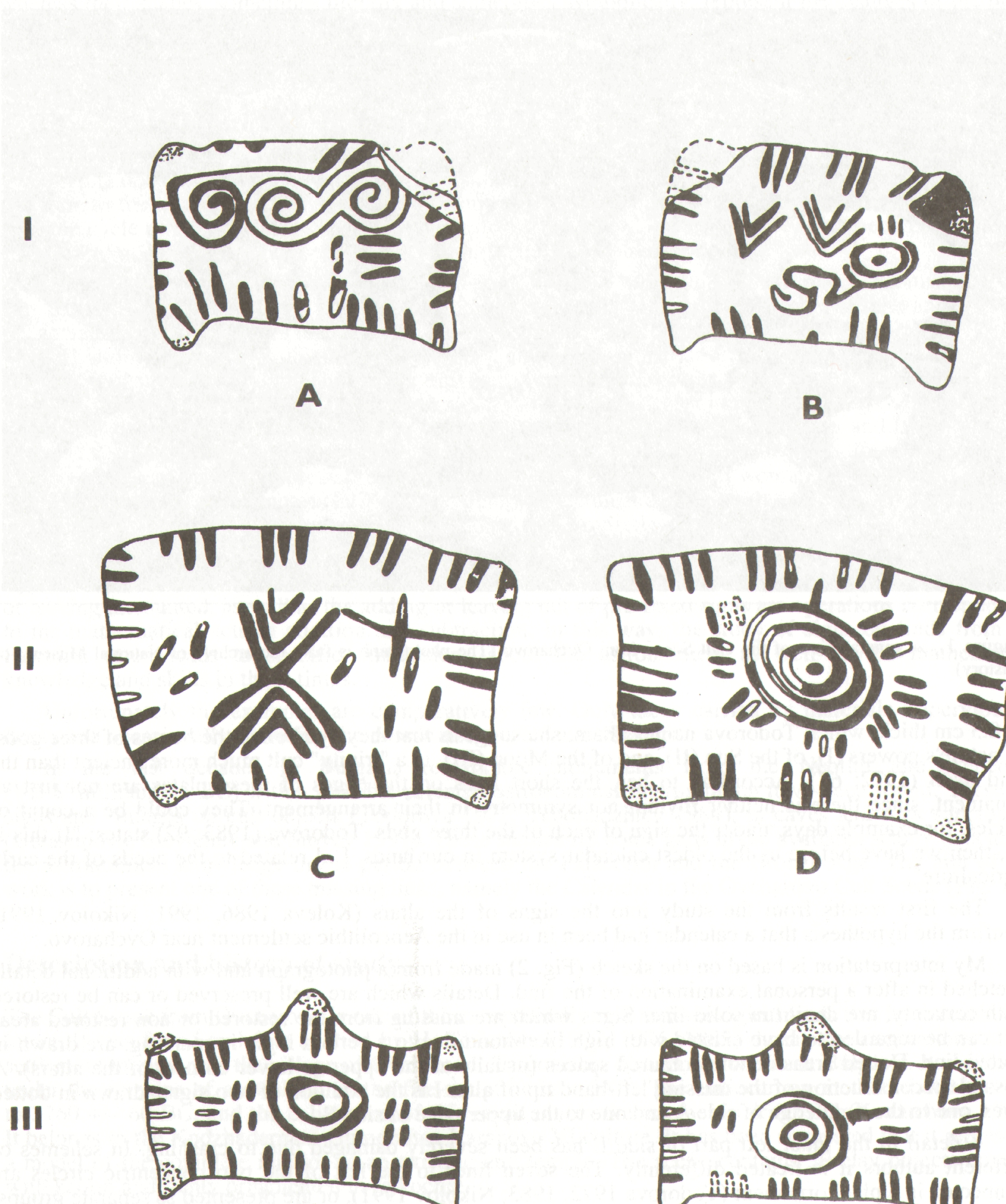

Figure 2. Sketches of the signs on the three altars, front and back: A and B (I altar), C and D (II altar), E and F (III altar).

Table 1

Altars' sides	⇧ upper (u)	⇩ down (d)	⇦ left (l)	⇨ right (r)	⇳ u +d	⇔ l + r	∩ l+u+d	∪ l+d+r	O total
A	4	12	6	6	16	12	16	24	28
B	8	7	8	7+1	15	16	24	23	31
C	13	7	8	7	20	15	28	22	35
D	13	9	8	7	22	15	28	24	37
E	8+8=16	12	6	8	28	14	30	26	42
F	6+7=13	15	8	6	28	14	27	29	42
A+B	12	19	14	14	31	28	40	47	59
C+D	26	16	16	14	42	30	56	46	72
E+F	29	27	14	14	56	28	57	55	84
A+C+E	33	31	20	21	64	41	74	72	105
B+D+F	34	31	24	21	65	45	78	76	110
A+D+E	33	33	20	21	66	41	74	74	107
B+C+F	34	29	24	21	63	45	79	74	108
A+C+F	30	34	22	19	64	41	71	75	105
B+D+E	37	28	22	23	65	45	82	73	110
A+B+C+ +D+E+F	67	62	44	42	129	86	153	148	215

Grounds for a calendar interpretation. Results.

Each calendar system is characterized by the basic time-measuring units used, by the period of their alternation and by the mechanism for introducing corrections; it is also defined by remarkable events: beginning and end of basic, astronomically and socially important days and "holidays".

The analysis of the signs on the altars of the Cult Scene shows that it is possible for the needed calendar components to be found and allows a pattern for their multiple use to be suggested.

1. The main elements which could serve for counting out of different time intervals are the lines that form the decorative frame of the altars. Their arrangement is discrete which facilitates their being read and memorised. Depending on their kind and location with respect to the neighbouring lines they form groups of 1 to 4 lines and the groups of 3 lines prevail. The signs on each edge are in most cases six, seven, and eight, more rarely 12 and 13, and in single cases four, nine, 15 and 16. The total number for each side is 28 (A), 31 (B), 35 (C), 37 (D), 42 (E), 42 (F), and for each altar, 59 (I), 72 (II), and 84 (III). The total number for the three altars is 215. The accuracy is ±1-2 lines.

In Table 1 are presented some of the possible combinations of grouping. The directions (left, right) are defined from the observer's position.

The reading of the signs on the bases and on the other three or four sides and upper edges separately, gives quantities with calendar-astronomical meaning.

Inserted in the string of lines, in some places there are some different signs. For example, on the upper edge of A the two signs to the left are very short, almost dots, while those to the right are lines directly connected to a single and a double spiral. The double spiral is enclosed in a meander-like figure. According to the analysis of ornaments typical of the epoch (Ribakov 1981) such spirals carry rich and sophisticated symbolism. I suppose they indicate the days that are the END and the BEGINNING of some time interval - month, year. Then the two short lines to the left of the single spiral could denote the shortest days around the winter solstice which is an important starting-point in many ancient calendars.

In the upper right corner of side B is situated a red-coloured triangle with one side lying on the edge and a free tip pointing inward. The triangle as well as the angles on this side are well-known symbols of fertility and of the femininity (Stoljar 1981). On C, again in the upper right corner, one of the horizontal lines is strongly elongated and crossed at a right angle by a shorter line, thus forming a cross-like figure. It is a widespread symbol of fire and the sun (Drößler 1981). Probably it marks the longest day in a year - the day of the summer solstice. A peculiar detail on the reverse side, D, seems to be the pair of perpendicular single lines, with barely touching ends, whose proximity draws attention to the upper left corner. One of them could mark the day of the autumn equinox. At the quantitative analysis I assume there could be cases when some of these signs are counted twice or are left out when counting (From now on I will refer to these as "correcting" days). I view the red-coloured tips as peculiar dividing marks in the sequence of lines. This is expressed especially well on the undulating upper edge of sides E and F.

The arrangement of the signs inside the frame of lines on the altars creates the impression of a certain plot, a kind of "story in pictures". It is also possible to count some of them, which is way I consider that they have an auxiliary function.

2. On sides A and B of the first altar the sum total of all signs on the four edges is 59 (28 + 31). Their average is 29.5 which is quite close to the synodical lunar month (29.53 days). In addition, 59 = 354/6 (354 is the number of days in the 12-month lunar year), and so 28 and 31 can count out the days of the large and the small months in a lunar calendar. Then, if the 31-day-long month begins and ends in the days of new moon, the 28 marks will count out only the days when the moon is visible during the next month.

That the period of 28 = 4 x 7 days is delimited on side A adds symbolic meaning to the side. This period is directly connected to the 280-day period of pregnancy of both the woman and the cow (28 = 280/10), and could be one of the symbols of the fertility idea in the Cult Scene. The counting out of 13 months, 28 days each, results in a 364-day-long year, close to the year of 365 days in the solar calendar.

By means of the signs on side B, the days in a solar year can also be counted out. If the triangle is added to the 30 lines not every month but every second month, the alternating 30- and 31-day periods will have an average duration of 30.5, equal to that of the 12-month solar year of 366 days.

The average duration of both years of 364 and 366 days is 365, which is close to the tropical year (365,24 days).

The number of months in the lunar and the solar year can be suggested by the 12 lines at the base of side A, while the days in the "week" (a unit of measure equal to 1/4 of the month) could be suggested by the number of lines (7) on the base of side B. The signs on the rest of the edges are 16 and 24, respectively, and may also have an implied calendar-astronomical meaning, for example 4 cycles of 4 solar years or 24 months in 2 years or 24 halves of (lunar) months in a year or ... 24-hour/part division of the day!

3. On the four edges of sides C and D of the biggest altar II the number of marks is 72 (35 + 37). On the two bases the signs are 7 and 9 respectively, and the total of the signs on the rest three edges is 28 for each side!

The total number can be linked to both the solar and the lunar year, since 72 x 5 = 360, the average of the two basic calendar units 354 and 366. Whether the cross-shaped sign on C is counted or not can change the sum of signs on C by 1. If it is counted twice, i.e. with the inclusion of its vertical line (a "correcting" day), the total will be 36, and if it is left out, 34 lines. The thus obtained numbers are 35 = 350/10, 36 = 360/10, and 34 = 340/10. Their tenfold counting with the addition of either 4 or 5 or 6 days gives periods close to the lengths of the lunar (350 + 4 = 354), tropical (360 + 5 = 365), and eclipse (340 + 6 = 346) years. The additional signs can be "read" from the groups of signs in the interior of side C: six angles in the middle and four-five lines to the right of them (including the vertical line from the "cross").

If the "rays" of the expressive solar symbol (22) are added to the 37 lines on D, the result is a sum already familiar from altar I : 59 days. The number 22 is equal to the doubled difference (2 x 11 days) between the solar and lunar years in a two-year calendar cycle.

A calendar with similar calendar cycle was used in ancient Rome during the second half of I millennium BC. It is supposed that the use of the number 22 as one of the intercalation periods is introduced already by Numa Pompilius, who reformed Romul's calendar about 690 BC. This calendar remains in history due to the inconveniences it caused to its coevals and the bewilderment of the descendants, because of its discrepancy both with the moon phases and the sun's motion. According to D. Lebedev (cited by Klimishin 1985: 205) it had been neither lunar, nor solar but "pseudolunar" and "pseudosolar".

The explanation lies in the Romans' superstitious adherence to odd numbers. I would also add that the priests had probably stuck zealously to the 2-year calendar cycle also because of some ancient calendar tradition with an astronomical symbolism, hidden behind the numbers, e.g. a lunar-solar-planetary tradition. My assumption is based on the fact that the main calendar units are the 355-day period, close to the 12- synodic-month lunar year, and the 377-day period, close to the synodic period of Saturn, and that their alternation in a two-year calendar cycle gives an average of the calendar year close to the tropic year (365.25 days).

Let us imagine that a similar calendar had been used in Ovcharovo, in which the common year has 354 days and the lengthened year has 354 + 22 = 376 days. Then in a 2-year cycle the average year will be 365 days long. In this case, the choice of the 37 signs on side D is hardly a coincidence (37 = 370/10) and acquires a calendar meaning. If, after the tenfold counting of the signs on D, the six angles from C are added, we get a period of 370 + 6 = 376 days, equal to the lengthened year of 354 + 22 days. If, however, to 370 we add the total of innermost lines (3+4 or 3+5) instead of the angles, we will get a number corresponding to the synodic period of the planet Saturn (378.09 days). Such a calendar could even be called "pseudo-lunar-solar-planetary".

When to 377 we further add the 22 lines-"rays" of the sun symbol on side D, we get another remarkable period of 399 days (the synodic period of Jupiter is 398.88).

These correspondences encourage a broader analysis of the signs on altar II, and as a result, the following correlations might be pointed out:

$$35 = 280/8,\ (35 + 1) + 37 = 73 = 365/5,\ 37 + 22 = 59 = 354/6,$$

as well as those related to the synodic periods of the planets:

35 + 22 = 57 = 114/2 (Mercury), 35 + 37 + 2 x 22 = 72 + 44 = 116 (Mercury),
37 + 22 + 6 = 65 = 585/9 (Venus), (35+1) + 37 = 73 = 584/8 (Venus),
35 + 37 + 6 = 78 = 780/10 (Mars), 72 x 12 + 2 x 22 = 216 + 44 = 260 = 780/3 (Mars),
37 + 22 + 4 = 63 = 378/6 (Saturn),
(35 + 22) x 7 = 399 (Jupiter), 37 x 9 + 3 x 22 = 399 (Jupiter).

4. The total of signs on the five edges of altar III is 84 (42 + 42). It has a strange shape reminiscent of a temple. In the case of this altar, separate examination of the basic and of the other 4 edges gives interesting results. If we trace the signs on the side edges and on the "dome", starting for example from the lower right corner upwards and leftwards, we will be able to trace in quantities the 4 lunar phases, as well as to describe the curve of the crescent before and after the phase of full moon that corresponds to the central tip and its 2-3 lines!

The base of E has 12 lines and the other edges have 30 altogether. These numbers on F are 15 and 27, respectively.

I presume that months are counted on the bases, and days on the rest of the edges.

Side E can serve to count out a year of 12 months, 30 days each, i.e. 360 days long. The adding up to a solar calendar year is produced by inclusion of additional days, as in the well-known solar calendar of the ancient Egyptians. One way to do this is to add, to the inner group of three horizontal lines, consecutively each of the four groups of vertical lines, namely (3 + 2, 3 + 2, 3 + 2, 3 + 2 + 1);

As a result we get a total of 21 additional days in a four-year-long solar cycle with 1461 days and an average year of 365.25 days. Here, too, a period of 377 days (13 x 29) is obtained which is close to the "Saturn" year (378.09),and additional correlations could be pointed out that are connected to the approximate values for the synodic periods of the planets:

42 = 378/9 and 27 + 27 = 54 = 378/7 (Saturn);
30 + 27 = 57 = 399/7 (Jupiter);
42 + 42 = 84 = 588/7 (Venus);
84 + 27 = 111 = 777/7 (Mars);
84 + 30 = 114 (Mercury).

5. It is interesting that the number of lines (27) on the four edges of side F is very close to the value of the sidereal (27.32 days) and eclipse (27.21) lunar month. If this number is specially stressed by separating the lines that comprise it on the four edges of F, then the number 346 = 10 x 34 + 6, which we obtained from side C of altar II, is hardly accidental. That the eclipse lunar month and eclipse year have been known, might mean that the eclipses of the sun and the moon have been purposefully observed and recorded. For a given geographical location on the Earth a relatively good repetition of the eclipses in terms of type and phase occurs during the period known already in ancient times, called "Saros". Its average length is 6585.5 days, = 18 tropical years and 10-11 days, = 19 eclipse years, = 242 eclipse months, = 223 synodic months.

One of the ways to count the days of this period is: (59 x 3 + 1) x 37 = 178 x 37 = 6586. The lunar half-years (177-178 days) are close to the time interval during which the optimum conditions for observation of eclipses set in - near the nodes of the moon's orbit and in the phases of new and full moon. They are counted by means of the 37 lines on D.

The days of the two lunar months (59), as it was already shown, can be counted from any of the altars. However, I consider altar I to be most suitable for this. The spiral figure on B resembling a snake which holds the sun or the moon in its gaping mouth, is a suitable depiction of an eclipse, while the triangle in the upper right corner may be a symbol marking the "dangerous" day after a half lunar year (28 + 31) x 3 + 1) and a mark for its additional counting out.

Another option for counting the days of the Saros on B is the alternating of periods of 30 and 30+1 days, with the triangle being counted every second month. As the average length of a month is 30.5 days, 216 months will be needed. A good approximation is given by the following combinations:

105 x 31 + 111 x 30 = 6585, or 106 x 31 + 110 x 30 = 6586.

Less precise is 107 x 31 + 109 x 30 = 6587, as well as 108 x 31 + 108 x 30 = 108 x (30 + 31) = = 108 x 61 = 6588.

The total number of months is again not accidental: it is equal to the sum of the signs on the side edges of the three altars: 216 = 215 + 1 (here one of the correcting-day marks is counted as a month). The counting of the months 105 + 111, 106 + 110, 107 + 109, and 108 + 108 can be done by different combinations of the altars' sides in threes:

105 = 28 + 35 + 42 and 111 = 32 + 37 + 42;
106 = 28 + 36 + 42 and 110 = 31 + 37 + 42;
107 = 28 + 37 + 42 and 109 = 32 + 35 + 42 or 109 = 31 + 36 + 42;
108 = 28 + 37 + 42 + 1(?) and 108 = 31 + 35 + 42.

Another reading of the signs on altar II shows the years and the additional days in the double Saros: 36 = (35 + 1) tropical years (C) and 22 days (the "rays" on D).

The ecliptic cycle is easily counted with the help of the lines on the altars and is found in the overall numerical construction?. Because of this it can be in the base of a "Great Year", consisting of 12 Saroses containing 216 full tropical years and a remainder of 132-133 days. These 132-133 days can be counted by the signs of the I and II altars: 28 + 31 + 35 + 37 plus 1-2 "correcting" days.

This is the known "eclipse" calendar cycle known also as "Pythagorean" due to the "perfection" of the numbers 12 and 216 (Lattice 1993: 101, Valev 1985).

As it was thus shown, astronomically significant quantities can be obtained with the help of only limited set of numbers and simple mathematical operations, employed also in an often similar fashion. This creates the impression that a numerical system with universal properties has existed which has made possible different calendar constructions.

The calendar

The first attempt to construct a calendar (Koleva 1986), was counting out of the days in the 12 months of the solar year from the signs on the edges of I and II altars in the following way:

3 x 28 + 3 x 31 + (2 x 35 + 1 x 22) + (2 x 37 + 1 x 22) = 365.

The assumption that by special signs certain astronomical events - equinoxes and solstices - have been marked necessitates specifying the duration of the seasons for the epoch 4500 BC. In the here presented scheme for reading, the correspondence of these signs with the beginning and/or the end of the seasons is more accurate.

I assume that the BEGINNING corresponds to the first day of the winter, which is marked, for example, with the double spiral on side A. Clockwise, 84 days are counted by three full readings of the 28 signs. The counting of the last 8 days of the winter season (84 + 8 = 92) is made from the lines along the upper edge of B in the same direction - from left to right. The first day of spring is therefore that which is marked with the triangle. Then follow three full readings (3 x 31) in the same direction, which give the 93 days of the spring season. So far, on altar I, the 92 + 93 = 185 days of winter and spring were counted.

We continue on side C, again clockwise, with the first summer day marked with the cross. All lines are counted twice (2 x 35) and a third time the lines of the cross - down along the left edge (6), then along the lower (7) and along the right (7) edge; in total 70 + 6 + 7 + 7 = 90 days for the summer season.

We continue, from the left corner of D to the right along the upper edge, with the day of the autumn equinox for which no special sign has been used. Then follows the reading of all lines twice (2 x 37) and only the 13 lines along the upper edge the third time, in total 87. The last three days of the season are counted out from the signs on the upper edge of side A: the two very short lines (almost dots) and the line connected with the single spiral, which is the END of the year cycle. Thus we get a total of 87 + 3 = 90 days for the autumn season.

Thus on sides C and D of altar II we count the 90 + 87 = 177 days, and the addition of the 3 days on side A of altar I gives the total 177 + 3 = 180 days for summer and autumn.

The year cycle then consists of 185 + 180 = 365 days.

In the proposed scheme, the solar year is an uninterrupted sequence of days in which the borders between seasons are marked by special signs.

It is remarkable that such a scheme follows relatively precisely the actual duration of the four seasons for the epoch 4500 BC (these are, according to my own calculations, 93.77 (WI), 93.16 (SP), 88.88 (SU), and 89.44 (AU)), and shows the equality between the warm and cold part of the year: 93 (SP) + 90 (SU) ≈ 90 (AU) + 92 (WI), or = 90 (AU) + (92 + 1) (WI), if the double reading of the correcting day - the triangle, is added.

I consider a serious test for the choice of this scheme to be the semantic analysis of the signs. The first results (Koleva 1986) show that their seasonal interpretation is possible.

Side B is suitable to depict the spring. The angles in the upper part are associated with young vegetation, e.g., sprouts of wheat, which was an important crop to the ancient tillers. In the lower part, "under the surface of the Earth", the ornament is rather symbolic. It could depict the body of a snake with the sun in its jaws. This can symbolize both the daily "birth" of the sun and the spring "awakening" of Nature, and the "dying" of the sun in the evening or during an eclipse. If a rare event such as the total solar eclipse has been observed around the day of spring equinox (marked with a triangle), it could have become a sign for the beginning of some time cycle or a kind of era in a certain chronological system.

A befitting symbol for summer is the stylized developed plant on C. In this scheme for interpretation it may be an image of mature wheat. Probably here the days of the next period - the ripening and reaping of the crops are counted. The cross, a symbol of fire and the sun, marks well the astronomical moment of the summer solstice, the turning point in the path of the sun.

Central on D is a solar sign, consisting of concentric circles and radiating lines - "rays". This expressive symbol of the sun on the largest of the altars is probably to show the special reverence for the sun. This gives reason to Todorova (1972: 63) to conclude that the sun cult has dominated the Aeneolithic society. In the autumn the fruits given by the sun to the Earth have been collected and possibly Sun worship has been marked with certain rituals in that same period.

The symbols on side A are very complex. The single spiral might resemble a snake, rolled into a ball during hibernation, and can be associated with the "dead" winter season. The double spiral, a dynamic symbol, is enclosed in a meander-like figure. This seems to depict the "conception", the beginning/birth of new life after the death of the old one. Such a vivid image of the borderline between death and life in Nature can mark the end and the beginning of different calendar cycles (month, year). The symbolic meaning of the 28-day-long lunar cycle, enhanced by that of the 280-day-long period of human female pregnancy, reveals the mythological perception of TIME with its cyclic renewal, continuity, and perpetuity.

Many of the farming and tilling activities are directly connected to the seasons of the year and already in ancient times the people have discovered a secure reference frame - the view of the night sky. It depends on the time of the year as well as on the epoch, due to the phenomenon known as precession of the Earth's axis. If we use the familiar constellations of the Zodiac, through which the yearly path of the sun passes, we can find out that in the epoch 4500 BC the beginning of spring, summer, autumn, and winter is marked by the sun's entering Gemini, Virgo, Sagittarius, and Pisces, respectively. If in the beginning of the winter, which is the start of the year, the sun is in Pisces, at the end of the autumn, at the end of the year it will be in Aquarius.

The additional semantic analysis shows an interesting possibility of using the figures on the sides of the altars to mark the four main constellations of that epoch, moreover, with a rather good approximation to their present-day symbols.

As a well-known sign of the waters and thunderbolts, and of the great creative force in Nature (Kouper 1993: 204-205) the spiral is also suitable to mark the constellations Aquarius and Pisces on side A. The groups of 2 and 3 angles on B, interpreted as young vegetation before, can be here treated to mark the celestial Gemini. Due to the mystical connection between plant and man (Kouper 1993: 179), the

fertility of the land is directly linked to motherhood. Similarly, the developed plant on C can be treated as an anthropomorphic image [2]. It resembles an erect female figure with pronounced slender waist and thick hip and raised upward hands (a similar pose exhibited the four female sculptures from the Cult Scene). I suppose that the figure corresponds to the constellation Virgo. Near its left hand is the fire symbol: the cross. Should this be an attribute of a celestial female person, it could be a torch or a weapon, e.g., a bow and an arrow, as well as an astral sign, such as the star Spica, the brightest in Virgo. On side D the solar symbol with the rays can be connected to the celestial Sagittarius - presented by means of the concentric circles collectively forming a bow or shield and the rays - arrows.

Of course, the symbolism here would require a much more detailed analysis, argument, and discussion, which lie outside of the scope of the present work.

The distribution of signs on the two altars I and II in the above - proposed scheme of a solar calendar, shows interesting mathematical-astronomical features:

- the sum of the signs on side A (84 + 3 = 87) and D (74 + 13 = 87) is equal to 174 = 29 x 6, and the one on B and C is 191/192, which is ≈/= 32 x 6, i.e. the divisibility by 6 determines two possible units for measuring of the 12 months in the solar year;
- the maximum sum of the signs on sides B (102), C (90) and D (87) is 279, which is ≈ 280, the days of the so-called "active", in terms of farming activities, period of the three seasons - spring, summer, autumn (Koleva 1986);
- the days counted out separately from altars I and II turn out to equal half of the lengthened and common year in the already considered two-year calendar cycle: 185 + 3 = 188 = 376/2 and 177 = 354/2. This allows us to assume also the possibility that a similar "pseudo-lunar-solar-planetary" calendar is constructed. It was shown above that on altar III the lunar months could be counted out and the typical lunar phases traced out, and also that an independent lunar or lunar-solar calendar could be constructed.

The measuring of time by means of different calendar units requires their synchronisation. The lack of sufficient correspondence with the lunar phases, e.g., at the end of such a two-year cycle, is compensated for after four two-year cycles. In this larger period of eight tropical years, there are 99 synodic months and five Venus years! But 27 eight-year cycles contain 216 tropical years equal to 12 Saroses minus 132-133 days, and 12 Saroses contain exactly 209 Saturns years! Such a calendar cycle may prove to serve the purpose of co-measuring the most important astronomical periods, i.e., to be lunar-solar and planetary-eclipse calendars at the same time!

Since the number 216 can be obtained by summing the signs on the edges of the three altars, and 132/133 is their sum on altars I and II, the days in 12 Saroses could really underlie the calendar in the Cult Scene and compose the Aeneolithic Great Year!

Conclusions

1. The results show that, if the signs on the Cult Scene are viewed as not simply decoration but as a record consisting of discrete numbers with certain content, an astronomical calendar interpretation is possible. Far from being coincidental, the location of those signs is carefully calculated. They resemble a pictographic or ideographic record. Bearing in mind the cult character of the find, it is logical to expect recorded information in code which would have been available only to the initiates. This might have been a calendar serving the needs of farming and cult activities, or natural and astronomical lore, or myths and legends about the world of gods and people. Just as likely, of course, it might have been sort of a game involving numbers and figures. That the ancient astronomers have described knowledge about the Universe using numbers means that they revered their magical powers. As is known, numerical mysticism is tightly embedded in religious systems.

2. The method used for decoding and obtaining numbers by adding and subtracting allows the construction of lunar, solar, planetary, and eclipse periods. These periods are almost never found in a straightforward way. There exists, however, a logical way for them to be obtained.

The results show that various ways to count out time intervals are possible - on each of the altars independently and in combinations. It is difficult to give a definitive answer as to what the type of calendar system used is. It follows from the clear polysemantics that the polyvariance is in the very concept of the system of signs, as well as in the character of the "reverse problem" to be solved. Because of this, and judging by the existing practices at different times, I accept that a solar calendar has been used

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2 This suggestion was made by G. Lazov, an expert of the National History Museum in Sofia, during a discussion.

for the needs of household and farming life of the Aeneolithic society in Ovcharovo, while lunar and combined (lunar-solar-planetary and eclipse-cycle) calendars have been used for the needs of the cult.

3. The records on the altars from the Cult Scene are a way of complex presentation of the Universe by means of figures, signs and numbers. They should be viewed as an intermediate (missing) link connecting the Paleolith calendars, too "complex" for their time, and the surprisingly "imperfect" calendars from more recent civilizations. Their similarities are probably due to an existing strict canon requiring that universal calendar systems, commensurable with various astronomical periods, be created. In this way, sacred knowledge about cosmic rhythms, about birth, evolution and death of the Universe, was preserved and transmitted.

The results allow me to conclude that the level of mathematical and astronomical knowledge had been surprisingly high, which can only be explained if we accept that the complex and long-lasting periodic astronomical events have been observed and recorded since very ancient times.

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